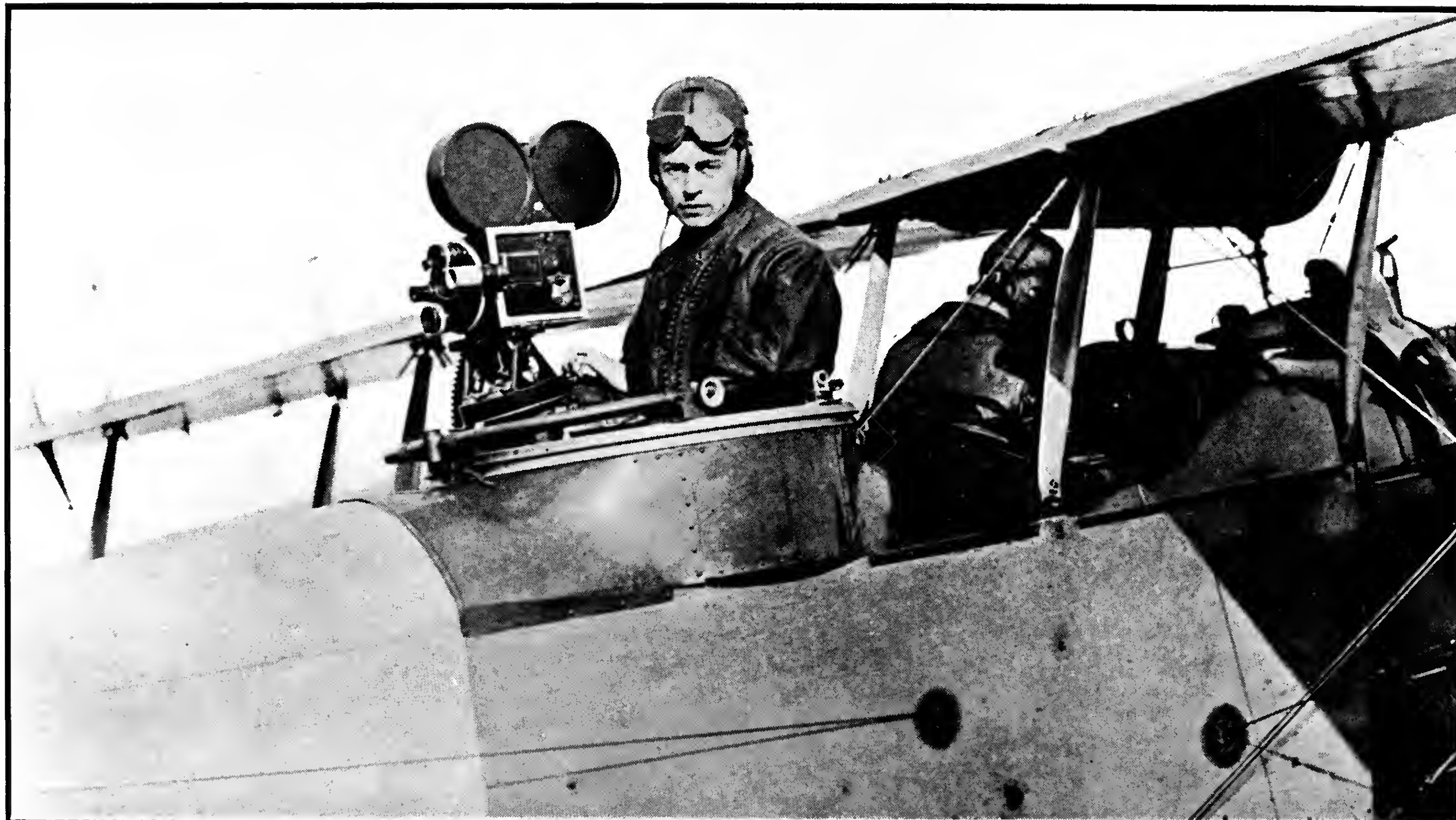
CONDENSED COURSE IN

# Motion Picture Photography

BY

NEW YORK INSTITUTE OF PHOTOGRAPHY



(*Photo by U. S. Signal Corps*)

THE EDITOR OF THIS BOOK, LT. CARL L. GREGORY, READY FOR A FLIGHT OVER NEW YORK CITY FROM MITCHELL FIELD IN A CURTISS JN-4.

A CONDENSED COURSE IN

# MOTION PICTURE PHOTOGRAPHY

*BY*


NEW YORK INSTITUTE
OF PHOTOGRAPHY

*WITH SPECIAL CHAPTERS BY*

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Formerly Cinematographer for Thanhouser, Edison, Pathé,
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*AND BY*

RESEARCH SPECIALISTS
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# INTRODUCTION

ACKNOWLEDGMENT would be a more fitting heading than the word Introduction. Acknowledgment is due to many men and to many companies for material and illustrations used in the production of this book. So many sources have been consulted for information that it is probable that the editor, whose work of annotating and correlating for this book has extended over a period of so many months of a busy life filled with writing, directing, taking pictures, teaching and many other activities, may perhaps have missed giving credit where credit is due.

For the main sources of information in the historical chapter, the editor is indebted to Homer Croy, C. Francis Jenkins, Henry V. Hopwood and, in a lesser degree, to many others.

Several standard text books on physics contributed to the chapter on Light.

Preparation for the Day's Work, Relationship of the Cameraman to Other Studio Workers, Applying for a Position, Trick Work and Double Exposure, and portions of other chapters are from the pen of Charles W. Hoffman, a versatile photographer and a deep student of photographic lore.

Photographic Solutions and The Tinting and Toning of Motion Picture Positives are contributed in their entirety by J. I. Crabtree, of the Research Laboratories of the Eastman Kodak Company.

For the chapter on Composition, the editor is indebted to J. C. Warburg.

Cutting and editing were taken largely from articles by Edward Roskam, R. J. Huntington and Alfred Biggs.

Publicity departments of film concerns and the apparatus manufacturers have been exceedingly generous in supplying cuts and photographs, credit for which is given in the legend under the pictures which have been used.

The editor has written many chapters but since so many authorities have been consulted and quoted without citing the source, he should be considered more as the editor and compiler of this book which seems to be needed by many workers and friends of the motion picture industry. Its value is obvious for those who have not the time or the opportunity to wade through the extensive but sketchy literature on the subject to reach a practical solution of the problems they may encounter in their everyday work.

While a work of this size can be in no way exhaustive, the editor has tried to retain as far as possible those details which explain the fundamental principles of motion picture photography to the average worker and at the same time serve as a guide and reference in his daily routine.

No attempt has been made to cover the details of special subjects such as cinematography in natural colors, photomicrography with the motion picture camera, ultra-speed pictures, motion study, etc., as any one of these subjects would easily require a volume the size of this and still not do justice to the subject.

In a work of this kind mistakes are liable to occur and while the manuscript has been carefully read and reread and the proof sheets carefully corrected by different persons, errors both of omission and commission may occur.

Should this Condensed Course meet with the success indicated by the interest of our students it will undoubtedly pass into a second edition in a short time. For this reason the editor will be glad to receive suggestions and criticisms for the improvement of the second edition.

Last, but most important of all, the officials and other instructors of the New York Institute of Photography have contributed to the success of this work through hearty co-operation and helpful suggestions from their actual experience of years in teaching students the interesting subject of Photography.

To all those who have thus assisted in the production of this Condensed Course in Motion Picture Photography, we wish to express our heartiest appreciation.

Carl Louis Gregory

Sutton Manor, New Rochelle,
New York, April, 1920.

## Chapter I

# HISTORY OF CINEMATOGRAPHY

IT is not impossible that some form of motion pictures was known to the Ancients. Titus Lucretius Carus wrote several volumes entitled "De Rerum Natura" at least sixty-five years before the Christian Era, wherein book four, verse seven hundred sixty-six appears the following, freely translated:

"Do not think thou moreover wonder that the images appear to move and appear in one order and time their legs and arms to use for one disappearance, and instead of it appears another arranged in another way, and now appears each gesture to alter, for you must understand that this takes place in the quickest time."

In the year A. D. 130, Ptolemy, a Greek philosopher, wrote a series of books on Optics, in which he not only described the phenomenon of persistence of vision, but also described a piece of apparatus in the form of a revolving disk with spots upon it, which demonstrated this phenomenon. Persistence of vision is a scientific term for the fact that the sensation of light coming from an object remains in the brain for an appreciable fraction of a second after the light has been extinguished. Whatever knowledge the Ancients may have possessed of motion pictures is too remote and too far buried in the murky depths of the past to be of more than momentary interest in the history of Cinematography.

The first step toward modern Cinematography took place about the year 1833, when W. G. Horner patented the Zoetrope, or Wheel of Life, which consists of a hollow cylinder turning on a vertical axis and having its surface pierced with a number of slots around the interior. Between the slots is a series of pictures representing successive stages of such a subject as a galloping horse, and when the cylinder is rotated, an observer looking through the slots as the wheel is rotated sees the horse apparently in motion. The pictures were drawn by hand, but photography many years afterwards was applied for their production. This did not occur until about the year 1877.

About the year 1872, Edward Muybridge, an Englishman employed in the United States Geodetic Survey, made photographs of a race-horse in motion. Muybridge made these at the instance of several race-horse owners, who had come to a hot discussion regarding the gait and mode of locomotion of their favorite steeds. Muybridge set up his camera with wet collodion plates (dry plates did not come into general use until sometime later) and made snapshots of race-horses at the Sacramento race-track. A few trials demonstrated that unless he could show rapid successive pictures of the horses in motion he could not settle the dispute. The contestants made up a fund with which he purchased twenty-four cameras and placed them at the edge of the race course, close together in a row with a fine thread attached to the shutter of each camera and stretched across the race-track, so that the horse in passing would break the thread and release the shutter of the camera, and thus make an exposure upon the sensitized plate. Each successive camera passed would then show a slight advance in action, with the result that by the time the animal had passed in front of the twenty-four cameras, he would leave a fairly accurate record which could be studied at leisure. The first results were not very satisfactory, as the sensitiveness of the collodion plates was not sufficient to get pictures in the small fraction of a second required to stop the motion. To overcome this obstacle, a fence was built at the side of the track in front of the cameras and painted black. If the horse being studied was not white, lines were drawn upon its limbs in white paint, so that with the help of the brilliant California sun, sharp well-defined silhouettes could be made at a much greater speed than had hitherto been possible.

Leland Stanford, Governor of California at that time, and an enthusiastic horseman himself, became very much interested in Muybridge's experiments. Governor Stanford was a wealthy man and furnished him with funds, to continue his animal study. A studio was built at the Governor's private race-track in Palo Alto, where Leland Stanford University now stands, and in this studio were placed the twenty-four cameras. Here it was that Muybridge conducted the major part of his experiments. Having succeeded in analyzing animal motion, he now proceeded to synthetize his results; or, in other words, to reproduce the movements of the animal so that they would be visible to the eye.

He finally produced a machine which would project the images of the glass plate upon a screen. He called this machine the Zoopraxoscope, probably with the intention of setting a record for a double-jointed polysyllabic word, which many others have tried to outdo. C. Francis Jenkins, in one of the first volumes ever published about motion pictures, gives a list of over a hundred coined words, which have been applied to motion pictures of which practically the only surviving one is Cinematography. Some of them were: Symographoscope, Chronomatograph, Chronophotographoscope, Photokinematoscope, Phantasmagoria and Getthemoneygraph.

The Zoopraxoscope consisted of a large glass disk, with the reproductions of the photographs set along its margin. A limelight was set up with a condensing lens, which would project the picture on a screen. This glass disk revolved continuously and the images on the screen were naturally blurred by this movement. However, the introduction of a shutter allowed the light to pass through each successive picture for a very short interval as each image came into place. These rapidly succeeding pictures produced the first moving picture on a screen.

It is interesting to note that in 1860, twelve years before Muybridge commenced his brilliant experiments the production of motion pictures by photographic men had already occupied the attention of scientists.

Sir John Herschel, the celebrated astronomer, who was also a brilliant chemist, foretold nearly sixty years ago the method used today in making motion pictures. It was he, who in 1819 discovered the solvent power of hyposulphite of soda on the haloid salts of silver, thus introducing it as a fixing agent in photography. His prediction of motion pictures was published in 1860 in the *Photographic News,* a leading journal of photography at that time. He says: "What I have to propose may seem to you like a dream, but it has, at least, the merit of being possible and indeed at some time realizable. Realizable—that is to say, by an adequate sacrifice of time, trouble, mechanism and outlay. It is the representation of scenes in action by photography.

"The vivid and life-like reproduction, and handing down to the latest posterity of any transaction in real life, a battle scene, a debate, a public solemnity, a pugilistic conflict (Heenan and

Sayers prize fight took place 1860), a harvest home, a launch—indeed, anything, in short, where any matter of interest is enacted within a reasonably brief time, which may be seen from a single point of view.

"I take for granted nothing more than—first, what photography has already realized or what we may be sure it will realize within some very limited lapse of time from the present date—viz., the possibility of taking a photograph instantaneously, of securing pictures in a tenth of a second; secondly, that a mechanism is possible, no matter how complex or costly—and perhaps it need not be either the one or the other—by which a prepared plate may be presented, focused, impressed, displaced, numbered, secured in the dark and replaced by another within two or three-tenth seconds.

"In fact the dismounting and replacing need only be performed within this interval; the other items of the process, however numerous, following these up in succession, and collectively spreading over as long a time as may be needful.

"There is a pretty toy called the phenakistoscope, which presents a succession of pictures to the eye, by placing them on a wheel behind a screen, and bringing each in succession to an opening in the screen of the size of the picture and thus allowing it to be seen. The eye is in like manner covered by a dark revolving screen, having narrow linear openings in it which allow glimpses through them precisely at and only at the instant when the pictures are in the act of transmitting the frame, and sensibly in the middle of the area.

"By this arrangement it has been found possible to exhibit figures in action, as dancers pirouetting, wheels revolving, etc., by having prepared a set of figures taken from one model presented at various angles to the visual ray.

"Coarse as the representations so made have been, the apparent reality of movements has been very striking. The persistence of the impression on the retina and its gradual fading obliterates, or glosses over, the hiatus in a way which would hardly be thought possible. Now there is nothing in the law of periodicity as regards the movements of the model, to influence the results, and we have only to substitute for such a periodically recurrent set of pictures imperfectly drawn by hand, perfect stereoscopic and simultaneous pairs of photographs duly presented to both eyes, in their natural order of succession to produce a stereoscopic picture in action."

In 1878, Muybridge published the results of his experiments, which excited great interest both in this country and in Europe; particularly among artists who had always been puzzled as to the correct attitude assumed by animals in locomotion. As soon as the results of Muybridge's experiments were published, demands came for him to appear before various scientific bodies to demonstrate his discoveries. His first appearance in Europe was in the laboratory of Dr. E. J. Marey in 1881, where he lectured to some of the foremost savants of France. Dr. Marey, himself, was intensely interested and established a studio for investigation of the motion of animals by similar photographic methods. He had already invented an instrument called the Marey Photographic Gun, which was shaped somewhat like a monster revolver and took twelve quickly successive images of a moving object, recording them upon a circular sensitive surface.

When Muybridge returned to this country, the University of Pennsylvania offered to equip a studio for him and furnish funds for carrying on his investigations. The studio, one-hundred-and-twenty feet long, was built on what is now known as "The Hamilton Walk" on the University campus. To carry his work much farther, he had to find a method of getting quicker exposures. He determined to solve the problem and achieved marvelous results, making many advances in the science of Photography. So well did he succeed that some of his photographs are unexcelled at the present day, many of them having been taken in the one-sixth thousandth part of a second.

In 1887, Muybridge, in collaboration with Dr. Edward Reichert, professor of Physiology at the University, made the first instantaneous pictures in medical research. A dog was given an anaesthetic, its chest opened, and the successive phases of the dilation and contraction of the heart were photographed. Thus the first motion picture record displaying the movements of any internal organs—human or animal—was made.

In February, 1888, Muybridge went to Thomas A. Edison, the inventor of the phonograph, and asked if his zoopraxoscope and the phonograph could not be synchronized so as to give the simulation of people speaking. Edison had not yet perfected the phonograph so that it was loud enough to be heard by a large audience and therefore could not consider the project at that time.

Muybridge published a book, "Animals in Motion," which is now used by artists in their studios, so that they may correctly delineate their subjects. It has proven a mine of information to those who produce animated cartoons and diagrams.

In 1893, at the Chicago World's Fair, Muybridge exhibited more than twenty thousand original photographs in his machine for showing them. In recognition of this the commission of the Exposition awarded him a certificate of honor. This marked the practical completion of Muybridge's work, as he was then an old man. He devoted more than twenty years of his riper maturity to the advancement of pictured motion. It is true that compared with the motion picture of today, his results were crude but they were pictures in motion nevertheless and he is honored and respected as the father of Motion Pictures.

Inspired by the work of Muybridge, many other investigators sought to produce the simulation of life upon the screen. Dr. E. J. Marey of Paris, was the most prominent of these. In 1890, he first used the celluloid roll film, which had just been given to the world through the efforts of the Rev. Hannibal Goodwin and George Eastman. Even before this, others had made partially successful attempts at using a flexible support for producing successive pictures from a single view point. As presented by Muybridge with his twenty-four cameras, the result achieved was the same as the modern device of moving a motion camera in an automobile or on a moving truck, traveling at the same speed as the object photographed—in other words, the object on the screen remained stationary, while the background moved past like a panorama.

Dr. Marey decided that the pictures must be taken from one point of view and applied himself to perfecting a camera which would take photographs in rapid succession from the same view point. In this he was successful, but, on account of the limitations imposed by the weight of glass plates, was unable to take more than a relatively small number of pictures at one time. Not only did the employment of glass slides require very elaborate mechanism, but the quantity of glass necessary prohibited the showing of more than a few short phases of action.

In 1876, Wordsworth Donisthorpe patented a mechanism for making photographs on a deck of glass plates, like a deck of


(*Courtesy Universal Film Co.*)

"DAREDEVIL" LT. O. L. LOCKLEAR AND MILTON MOORE, HIS CAMERAMAN.

cards, pushed to the focus of the lens and exposed, one at a time, then dropped down and out of the way of the next plate, at the rate of eight exposures per second. In his patent he makes this claim, "If the apparatus be arranged to take successive pictures at sufficiently short intervals of time, they may be printed at equal distances upon a continuous strip of paper. This paper, with the series of pictures upon it, may be used in the instrument known as the Zoopraxoscope, or Wheel of Life. To allow of this, the strip of paper may be wound on a cylinder to be unwound from it, at a uniform speed, unto another cylinder, and so carried past the eye of the observer, any ordinary means being used for any showing that each picture shall be exposed momentarily to the observer. By this means, the movement made by a person or group of persons, or of any other objects during the time they were being photographed, may be reproduced to the eye of the observer." With this apparatus he photographed and reproduced growing grass, buds developing into flowers, and the metamorphosis of frogs. Thus he was the first to take "stop motion" pictures.

The period from 1889 to 1893 might be termed the gestation period of what we still love to term our infant industry.

The invention of the motion picture is ascribed by many to Thomas A. Edison, but so many other scientific men were busily engaged in trying to solve the problem of producing motion pictures in a commercial way at this time, that it is difficult and probably unjust to give the credit entirely to any one man.

Dr. Marey, so far as is known, was the first to use the flexible sheet celluloid, but it is probable that the same instant that Dr. Marey was carrying on his experiments in Paris, W. Friese Greene and M. Evans were using paper film for the very same purpose in England. In 1899, they filed application for patent on a machine for taking and projecting moving photography by means of a ribbon of successive photographs. On the other hand, a brochure published in 1895, and bearing Edison's entire endorsement, lays claim to his being the prior inventor as follows:

"In the year 1887, Mr. Edison found himself in possession of one of those breathing spells, which relieved the tension of inventive thought. It was then that he was struck with the idea of producing on the eye the effect of motion by means of a swift and graded succession of photographs. The initial principles of moving images was suggested to him by a toy, the Zoopraxoscope, or Wheel of Life. It was determined to revolutionize the whole nature of the proceedings, by instituting a series of impressions fixed to the outer edges of a swiftly rotating disk supplied with a number of pegs, so as to project from under each picture on the rim. A Geissler tube was placed, connected with an induction coil, which, operated by the pegs, lighted up the tube at the precise moment when the picture crossed its range of vision."

Curiously enough, during all of this period, when men like Marey, Edison, Evans, Demeny, Donisthorpe, Jenkins, Anchuetz, and many others were working upon the problem of photographing pictures in rapid succession, very little attention was paid to the problem of projection, because their ideas were centered upon the use of the pictures for individual observers in coin operated slot machines. Although a number of the patent specifications include the use of the camera mechanism, or a similar mechanism for purposes of projection, very little actual work seems to have been done toward solving the problem of presenting motion pictures to a multiple audience. Numerous authentic examples of motion pictures taken by various inventors at this period are in existence today, but it is probable that the first public exhibition to an assembly of people was given by C. Francis Jenkins on June 6th, 1894, in his father's shop at Richmond, Indiana. Jenkins was at that time a stenographer in the treasury department at Washington, D. C., and, in his spare time had been experimenting in the making of motion pictures.

Jenkins writes of his first inception of interest in the subject as follows:

"In 1885, while standing one day on a high prominence in the Cascade Mountains, I watched the reflections of sunlight from the axes of some working men clearing the right of way for a railroad in the valley below. The reflection from two or three hundred axes produced a peculiar scintillating and beautiful effect. From that moment I date all of my efforts to achieve what finally resulted in the perfection of the chronophotographic apparatus I have built and used.

"My experimentation was dependent upon what could be spared out of a small salary. This is my excuse for the delay in completing a commercial machine after the first conception of the phantoscope, which is simply a fanciful name for the various devices I have employed in this work—the different steps of which may readily be followed by an inspection of the old apparatus now on exhibition in the United States National Museum.

"My active efforts were begun in 1890. Of course, first of all, pictures were to be secured. The first apparatus built for this purpose consisted of a rachet rotated drum, upon which the film was wound to feed it past the point of exposure. The camera made a succession of pictures upon this film by short exposures—the film being jerked forward the width of one picture in the interim. Two shutters were supplied—one with a narrow opening employed when the apparatus was used as a camera, and the other having an opening three-fourths of the complete circumference of the disk employed in reproducing the pictures. The amount to cut away in the shutter was determined wholly by experiment. The film was wound upon the drum intermittently by a pawl and rachet arrangement. In reproducing the pictures, an oil lamp was used to project them upon a small screen. By accident the camera was found to be so constructed that it would take pictures without a shutter.

"This seems at first glance incredible, but as the film gets only just sufficient exposure during the period of rest, the light is too weak to affect it during the movement of the film, for if five pictures per second were made and the exposure exceeded by fifteen times, the time necessary to move the unexposed portion of the film into position, and the period of exposure should be just sufficient to make a fully timed picture, then the remaining one-three-hundredth part of a second would be too small to perceptibly affect the film and a shutter would be unnecessary.

"In these early experiments, the film was not perforated. At this time, the manufacturers did not keep a stock of film of any widths in considerable lengths. This convenience came later. So the longest film obtainable was split in the widths of about two and a half inches by drawing wide film beneath knives set in a board."

This first exhibition at Richmond, Indiana, could not be properly termed a public exhibition, as no admission fee was charged, but he followed this with a public exhibition in August, 1895 at the Cotton States Exposition in Atlanta, Georgia. So incredulous were the people at the exposition that less than one hundred persons could be induced to pay an admission fee of twenty-five cents to see motion pictures—a word which had not then been coined. The ballyhoo, or announcer, failed utterly to convey to the minds of the passing populace what they would see in the exhibit. Finally, in desperation, he decided to invite the crowd to enter for nothing, and after the show was given, it was explained from the platform that those who so desired, might deposit a coin in the ticket box as they went out.

The interest aroused by those who saw the exhibition was such that it promised to be a success, but just as the young inventor had commenced to spend in his imagination the money he would make, a fire broke out in one of the neighboring concessions, destroying not only the exhibition hall, but a number of buildings surrounding it.

Between the time of exhibiting the pictures in Richmond, Indiana, and the unfortunate catastrophe at Atlanta, Jenkins formed a partnership with another young man, Thomas Armat, who had worked with him in building the two projecting machines which they took to the fair at Atlanta. Armat's father was a manufacturer of some means, so Armat was able to continue his experiments while Jenkins was compelled, for financial reasons, to return to work in the Treasury department. Jenkins' inability to devote his entire time to experimentation resulted in a breach between the co-workers, which finally resulted in a number of legal controversies which dragged through the courts for a long time.

Discouraged by lack of popular interest in his projection machine, Jenkins came to believe that it was of interest only to scientific bodies, and on December 18th, 1895, read a paper before the Franklin Institute of the state of Pennsylvania, in which he described and showed in detail the working of the Phantoscope.

Meantime, Armat, working independently, made another machine, which he showed to Raff and Gammon, a firm largely interested in the penny peep shows prevalent at that time. They were the agents for the Edison coin-controlled Kinetoscope, which exhibited to one person only. Raff and Gammon did not display much interest in the Armat machine until the next year, when Jenkins set up his machine in a hall at Atlantic City directly opposite a peep-hole show. The managers of the slot

(*Courtesy of the International Film Service Company*)

NEWS CAMERAMAN EDWARD GUETLEIN STANDING BY HIS MOY CAMERA, SPECIAL MODEL FOR NEWS WORK.

machine arcade complained to their principals in New York, who investigated the cause for the falling off of patronage. People found it much more comfortable to sit in an orchestra chair and watch the pictures on the screen than to stand in an awkard position at the peep-hole of a slot machine. This stimulated Raff and Gammon to a new interest in the Armat machine, for although Edison had been working upon a projector, he had abandoned it for other matters. Raff and Gammon, therefore, made arrangements to have the Armat machine, which was copied from Jenkins' original model, manufactured in the Edison shops to be put out as the Edison Vitascope. The following letter from Raff and Gammon to Armat shows how the original Jenkins' invention came to be known as the Edison machine:

"Kinetoscope and phonograph men and others have been watching and waiting for a year for the announcement of the perfection of the Edison machine which projects kinetoscope views upon a screen or canvas. No matter how good a machine should be invented by another, and no matter how satisfactory or superior the results of such a machine invented by another might be, yet we find the greatest majority of the parties who are interested and who desire to invest in such have been waiting for the Edison machine and would never be satisfied with anything else, but will hold off until they find what Edison can accomplish. We find that many of these parties have been approached in the last few months to invest in other similar machines, but they hesitate to do so, evidently believing that Edison would in due time perfect and put out a machine which would cast the others in the shade.

"This being the case, you will readily reach the same conclusion that we have—that in order to secure the largest profit in the shortest time it is necessary that we attach Mr. Edison's name in some prominent capacity to this new machine. While Mr. Edison has no desire to pose as inventor of this machine, yet we think we can arrange with him for the use of his name and the name of his manufactory to such an extent as may be necessary to the best results. We should, of course, not misrepresent the fact to any inquirer, but we think we can use Mr. Edison's name in such a manner as to keep within the actual truth and yet get the benefit of his prestige. The machine might be made with a place upon which we could inscribe the words "Armat Design" or something of that kind, and you understand that after we have disposed of our territory and the business is fully established, and we have reaped the respective rewards, we will then make it our business to attach your name to the machine as inventor, and we are confident that you will eventually receive the credit which is due you for your invention. We regard this as simply a matter of business, and we trust that you will view it strictly in this light."

Jenkins and Armat, before their dissention, had made a joint application for patent, which had not yet been issued on account of the friction between them. Armat, in order to clear the situation between them, offered to buy Jenkins' interest in the joint application, and finally induced him to accept twenty-five hundred dollars in cash for his interest. Having disposed of his principal asset in the infant industry, Mr. Jenkins turned his major attention to other inventions, and ceased to be a factor in the game until recently he entered extensively into the manufacture of projecting machines and also organized the Society of Motion Picture Engineers.

Having thus briefly reviewed the early history of the motion picture up to the point where the first crude projectors of the present type were evolved, we will leave this subject to pass on to present-day practices. To give even a skeleton synopsis of the development of the industry from that time to this would fill several volumes the size of this. The student who wishes to delve into the past can consult the many books mentioned in the bibliography and the bound volumes of motion picture periodicals in the libraries.

## Chapter II

## FASCINATION OF CINEMATOGRAPHY

MOTION pictures cover a field that is almost universal, and the person who is skilled in taking pictures with the cinematograph camera, or interested in any of the pursuits intimately connected with its operation, practically has an unlimited field in which to exercise his creative energy.

Wander-lust, the desire to see strange countries and foreign peoples, is a longing which many possess, but few are able to satisfy. Many a man with a longing to travel and see the far stretches of the world has been able to pay all the expenses of his globe-trotting, and pocket a bonus, by taking along a motion-picture camera and bringing back to his less fortunate friends an interesting intimate reproduction of the sights and scenes which have held his interest during his journey.

The making of dramatic pictures covers a field of ever varying novelty that is the very antithesis of monotony.

There is scarcely a trade or profession in which cinematography has not important and direct relation to its improvement and expansion.

There is no doubt that by the aid of the motion picture, the duration of the great world war was very considerably shortened. In no other way could the tremendous amount of propaganda and information concerning the war situation have been made clear to the populace. The committee on public information, in conjunction with the government, sent out thousands upon thousands of feet of motion picture film, showing the activities of the government and of the army and navy. All of the allied war charities attribute their ability to raise tremendous sums for philanthropic purposes mainly to the agency of motion pictures. Thousands of men and women were engaged in making propaganda films of all kinds. The war loan committee, aided by the motion picture industry, made thousands of feet of film to stimulate the loan drives.

In educating and training our army and navy, the motion picture was of incalculable value. So remarkable have been the results achieved in the training of men by the use of motion pictures that it is freely and confidently predicted that tremendous and important as is the production of motion pictures for amusement and entertainment purposes, in a comparatively short time to come that use will be relegated to a position of insignificance in comparison with the tremendous production of motion pictures for educational and pedagogical purposes.

In the making of these pictures, thousands of craftsmen have yet to receive their training. The government of the United States, realizing the tremendous importance of motion pictures as an educational factor, is establishing a bureau in Washington for the production and distribution of educational pictures to be used by schools, churches, colleges, community organizations, and welfare units. The film manufacturers, who have hitherto been blind to the educational possibilities and the financial opportunities presented, are now eagerly seeking to make up for lost time and are hastening their preparations to supply the rapidly growing demand for this kind of picture.

"Educational" is a much abused word, which, in the past, generally meant to the exhibitor and show-man, a scenic picture or an industrial picture of haphazard construction, which, more often than not, acted as a chaser to drive people from the theatre. Gradually, producers of scenic, industrial, and educational pictures came to realize that unless their product was made with the same care, as or even greater care, than that devoted to the production of dramatic pictures, they could not continue to exist. Today, people of specialized training in nearly every profession are being employed in the studios and laboratories of producers of educational pictures in order to make them more interesting and instructive.

Thousands of manufacturers are using motion pictures to instruct and amuse their employees, and have found in them, one of the most powerful antidotes for labor troubles and social unrest. In no other manner can the destructive conditions caused by labor troubles be so forcibly and favorably impressed upon the mind of the workers.

All of this is quite aside from the use of motion pictures for the advertisement and exploitation of the manufacturer's pro-


(*Courtesy of Fox Film Corporation*)

WILLIAM FARNUM TAKES A HAND BEHIND THE GUN WITH A PATHÉ PROFESSIONAL.

duction. Here is another avenue for the disposal of the product. One of the greatest problems in connection with the demonstration of large and not easily portable pieces of machinery has been that the customer could not see these machines in operation. Today the manufacturer's salesman can carry a portable projection machine, less heavy and cumbersome than a well-packed suit-case, with a reel or reels of film, with which he can demonstrate upon the walls of his customer's office all of the possibilities of which the machine is capable, with far greater brevity, and often, with greater clarity than he could demonstrate the actual machine in operation. By means of close-up views, enlargements, and animated diagrams, he can show details and features that could not be demonstrated even by the operation of the machine itself.

For the production of pictures of this kind, thousands of camera and laboratory and technical workers must be trained. Authors of industrial scenarios, directors, who understand the intricacies of complicated machinery and of industrial and manufacturing processes; camera operators, who can photograph the things which the directors wish to show; title writers and film editors for placing the photographer's scenes in logical and interesting continuity; laboratory workers to turn out prints of the highest photographic quality, tinted and toned in attractive colors; all are needed for this rapidly growing industry.

The film reporter, gathering the topical news of the day with his motion picture camera, lives a strenuous but intensely interesting life. He must be ready at a moment's notice to take his grip and motion picture outfit and travel to any point on the globe to feed the insatiable appetite of the news-loving public for minute details of the latest event. In the larger cities, the big theatres are slow indeed, if they do not throw upon the screen on the same day that it happens, any event of importance taking place within two or three hours' ride of the city.

Besides the news events, thousands of short subjects of more general interest have brought the Animated Screen Magazine into existence. In the same way that the animated newspaper satisfies the curiosity of the public for the latest news, the screen magazine treats all the latest topics of the day in much the same manner as the popular magazine. It has this advantage over the magazine, compelled to confine itself to cold type and still pictures;

it can show operations, movements, and animated diagrams in a few seconds' time, that pages of print could not half so adequately explain.

It is obvious that this branch of the business must fall largely into the hands of the unattached or independent worker, who bears the same relation to the picture theatre as the outside correspondent to the newspaper. A firm engaged in supplying news films cannot hope to succeed without amateur assistance. No matter how carefully and widely it distributes its salaried photographers, numberless events of interest are constantly happening—shipwrecks, accidents, fires, sensational discoveries, movements of prominent persons, and the like, at places, beyond the reach of the retained cinematographer. For film intelligence of these incidents the firm must rely upon the independent worker.

Curiously enough, in many cases, the amateur not only executes his work better than his salaried rival, but often outclasses him in the very important respect that he is more enterprising. Acting on his own responsibility, he knows that by smartness alone can he make way against professionals. Only by being the first to seize the chance can he find a market for his wares. Thus when Blĕriot crossed the English Channel in his aeroplane it was the camera of an amateur that caught the record of his flight for the picture theatres, although a corps of professionals were on the spot for the purpose. True, the successful film showed many defects. But defects matter little compared with the importance of getting the picture first or exclusively. Plenty of similar cases exist. The amateur has an excellent chance against the professional. His remuneration, too, is on a generous scale. The market is so wide and the competition so keen, especially in New York, the world's centre of the cinematographic industry, that the possessor of a unique film can dictate his own terms and secure returns often twenty times as great as the first cost of the film he has used.

Aside from the wide field of entertainment to which most of the products of the motion camera are devoted it is daily broadening its scope in the field of scientific investigation. Technical laboratories are daily finding new and diverse problems in the solution of which the cine camera plays an important rôle.

Scientific research has received a mighty and tremendous impetus in this country through the conditions arising from the great world conflict. We are just beginning to realize how dependent we have been in allowing foreign brains to solve for us the great bulk of the more complex industrial processes and the awakening finds us determined and able to take and retain the leadership in this important task.

Efficiency means the elimination of waste—one of our greatest wastes is time waste; every excess movement wastes a precious interval of time; the cine camera has become a detective, sleuthing out the thieving excess motion which steals valuable time.

Frank Galbraith, a noted efficiency engineer, has, by the use of motion pictures, succeeded in eliminating false and useless motions to such an extent that various factory operations have been speeded up so the output has been increased as much as three and four hundred per centum. Marvelous as it may seem, the worker was able to turn out this increased amount of work with much less fatigue than when he had done a less amount under the haphazard régime.

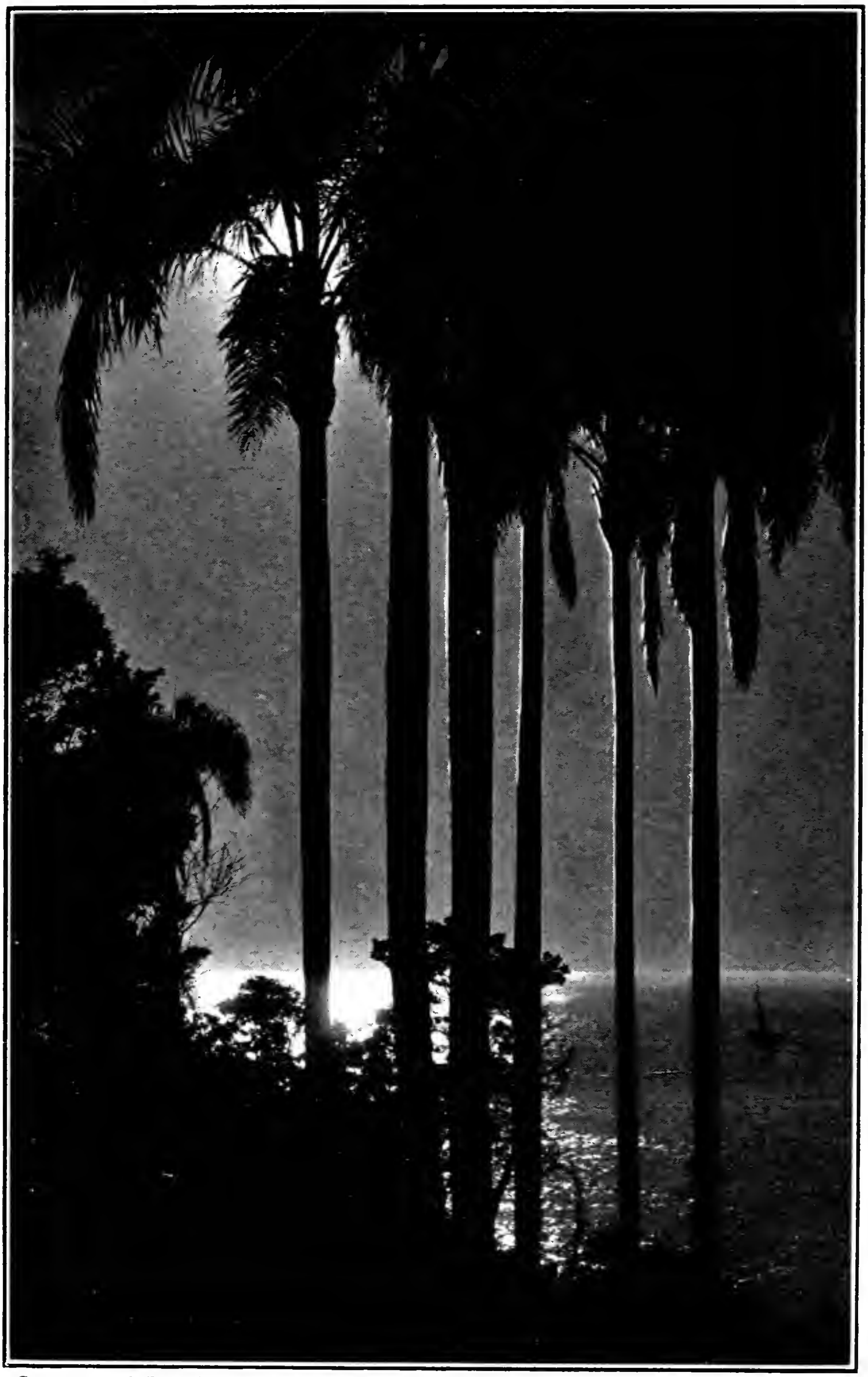
When the motion camera is used for time studies, a split-second clock is generally placed in the picture and photographed at the same time, thus giving an accurate record of the time interval between each frame or picture on the celluloid tape.

Percy Haughton, the Harvard football coach, has adopted the motion camera for revealing the faulty and unnecessary motions of players on the football field. Every fraction of a second gained on the athletic field is a big boost toward victory.

A picture released about a year ago by one of the large companies excited much comment and illustrated how motion pictures may prove of great service in correcting faulty muscular action. The picture showed an athlete in various simple gymnastic feats such as walking, running, jumping and shot-putting, taken simultaneously with two cameras. One camera took the action at the ordinary rate of sixteen pictures per second, while the other camera made one hundred exposures to the second; the normal and the ultra-speed pictures were projected one after the other at the normal rate of projection thus prolonging or amplifying the ultra film to nearly six times the duration of the normal motion. It was very weird and interesting; the ease and deliberation of the prolonged action gave time for the study of every movement and the play of every muscle. One could not help but marvel at the co-ordination of the work of the muscles. The figure of the athlete seemed like a diver immersed in crystal clear water, the buoyancy of which floated him through the graceful attitudes of his movements.

As ordinarily shown, motion pictures are taken and projected at the rate of sixteen pictures per second, but for the scientific investigator the rate of speed may vary from as high as 30,000 to the second in the study of high speed phenomena to as low as one exposure per hour or even one exposure per day, as used in studies in the change of structural materials, or the growth of a plant. All of these may be projected at normal speed for screen study or each frame may be subjected to individual scrutiny under the magnifying glass in special cases as in seeking to eliminate lost motions in machine assembly, etc.

Reduced to normal projection speed, bullets swim across the screen like leisurely fish and bursting shells separate like a group of mosquito wrigglers. Many high speed processes, such as the flow of steam; air and gases; combustion and explosions; automobile engines; the action of governors; the synchronism of electric generators; the flow of water in turbines and water wheels; the action of steel and wood-working machinery; and machine tools; etc., may be photographed at high speed and slowed down in projection so that they may be studied with the greatest accuracy.



(Courtesy of E. Fink, Graduate of N. Y. Institute of Photography)

SCENE NEAR NIEMEYER AVE., RIO DE JANIERO.

## CHAPTER III

# THE NATURE OF LIGHT

AS the whole structure of photography rests upon the application of the science of physics and chemistry, the student of photography or of cinematography can never be too well informed upon these subjects. While we shall endeavor to merely touch upon the more important principles of physics and chemistry which are most intimately concerned in their relation to photography, it would be well for the reader, who is earnestly in search of information, to dig up his high-school text-books and study the subjects of the physics of light and the chemistry of the salts of silver. If he has no such books, he will find a mine of interesting information in the public libraries, which are so numerous over the country that there are very few who do not have access to them. He who has considered these subjects dull and uninteresting will find they contain an unsuspected interest when he comes to trace their relation to and use in photography. It is not necessary to go deep into these subjects to get the simple facts upon which photography is based. When one has a clear conception of these facts, they will form a firm foundation upon which to build a sound structure of photographic knowledge. New facts acquired will then fit upon this foundation like bricks into a wall. If the student is uncertain as to what books to consult to acquire the knowledge which he wishes, he may find some assistance in consulting the bibliography or list of suitable text-books given in another place in this volume.

It is hardly two hundred years ago since people first had any adequate idea that our atmosphere exists and that we live and move about at the bottom of a sea of air—the weight of which presses upon us and all other objects about us with a pressure of approximately fourteen pounds to the square inch. With our present day knowledge gained from barometers, air-ships and balloons floating in the air, and from hundreds of other common facts, we accept the presence of the atmosphere as a matter of course.

The existence of an all pervading ether is, however, somewhat more difficult to grasp. Much like our knowledge of the air, its existence is only an inference from observed facts. Ether is an all-pervading medium in which the entire universe is submerged, and by means of radiation or vibration, are transmitted light, radiant heat, actinic radiation, X-rays, electro-magnetic oscillations, magnetism, and Hertzian waves. Of these forms of radiant energy, light, or those radiations which enable the eye to see objects, are the only ones with which we are to deal.

Light is transmitted through the ether in straight lines, by very minute waves or vibrations, which travel with great rapidity.

For purposes of comparison, we often refer to the similarity of light waves to sound waves, but sound waves are carried by

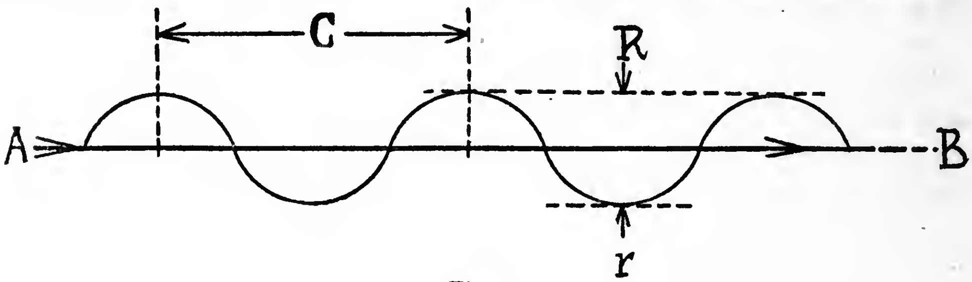



Fig. 1.

A B represents a minute section of a ray of light traveling in the direction indicated by the arrows. The curved line represents light waves. The distance from crest to crest of two consecutive waves is the wave length designated by C. The distance Rr from the crest to the bottom of the curve is called the amplitude of vibration.

the atmosphere at a comparatively slow rate. It will be noted when viewing the steam emitted by a whistle at some distance from the observer that the steam is seen some little time before the sound is heard, showing that the light waves from the object travel much more quickly than the sound. Ether waves do not correspond to sound waves in some other respects. For instance, sound waves are composed of alternate compressions and refractions, while the wave movement or displacement in light waves is from side to side at right angles to the direction in which the light wave is traveling.

Figure one is an illustration of the movement of light waves from side to side as it might appear if it were possible to magnify a ray of light and render it visible. Light itself is not visible. When we say we see a ray of light, as we sometimes do when the sun-shine falls through a window or through the foliage of trees, we do not actually see the ray of light—what we see is small particles of dust floating in the atmosphere which show us where the ray of light is passing. The particles of dust reflect to our eye a small portion of the light which comes through the window or between the leaves, as the case may be. In ordinary diffused light, these particles are too small to be seen, but under the strong light of the sun, each particle becomes a tiny luminous point.

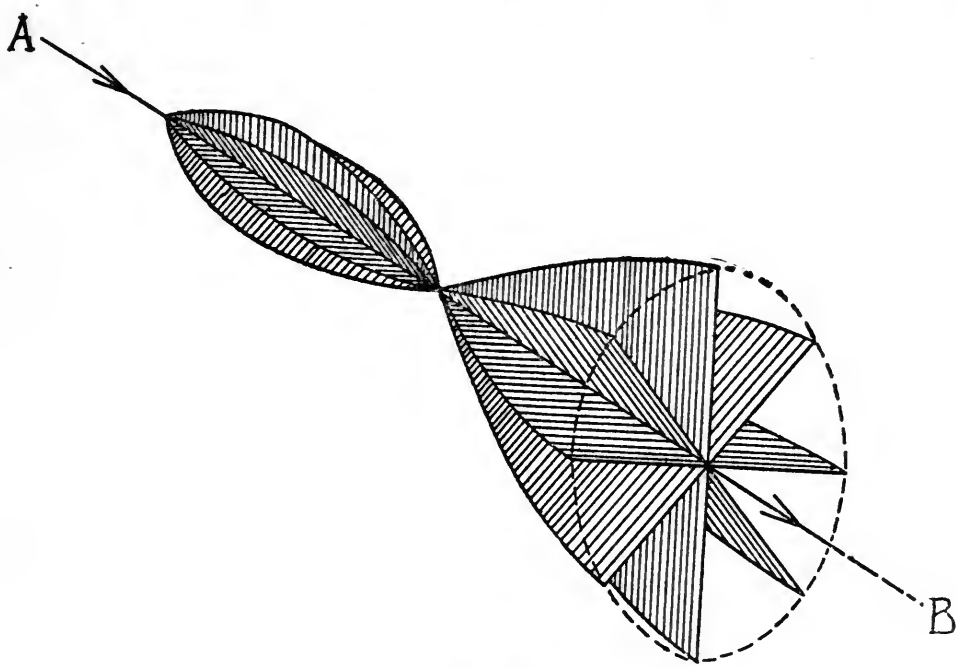



Fig. 2.

This drawing is an attempt at showing figure one in perspective with the purpose of revealing the fact that the curved line of figure one not only extends up and down but in every conceivable direction at right angles to the direction of propagation A. B.

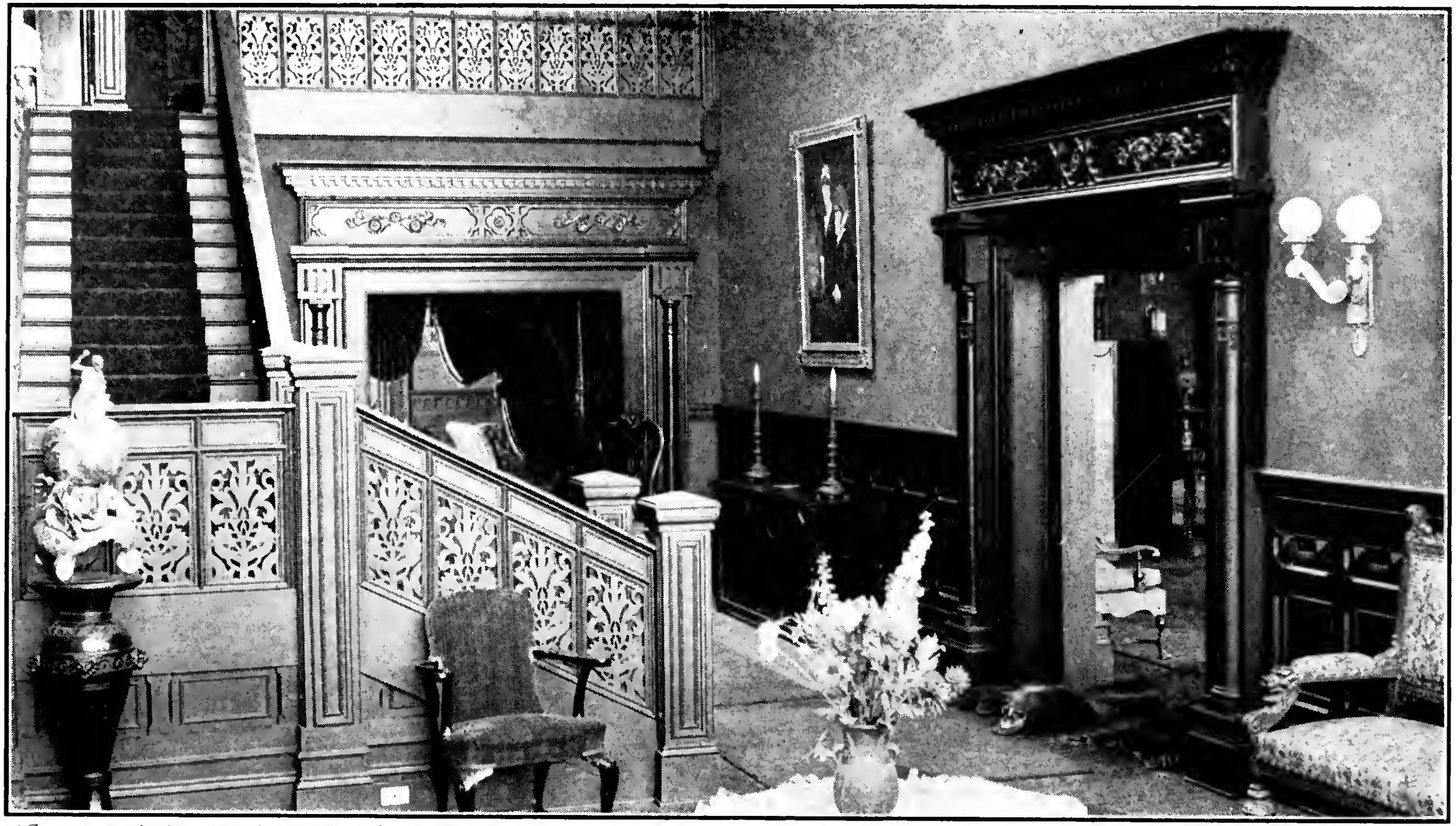
For an experiment to prove this, turn the light of a projection machine on in a quiet room, and if the atmosphere has not been disturbed so as to stir up dust, the path of the light will not be visible, but if we stir up a little dust, or blow a puff of smoke in front of the machine, we will see the path of the light spring out so that we can see it distinctly.

To return to the vibration of the ether waves back and forth in a ray of light, we see that in the first diagram the waves are represented as traveling like the crests and hollows of waves on water, which move forward without moving the water which composes them forward. This we know, because a boat floating upon water agitated by waves, does not move forward with the waves, but simply bobs up and down in the same spot. In the same manner, light waves pass through the ether without the ether moving forward in the direction of the waves. There is a difference in the light waves and the water waves, however; for while the waves in water move up and down only, the vibrations, or waves, which occur in the ether, take place in every conceivable direction—sideways as well as up and down. Figure 2 represents a cross-section of a ray of light in which may conceive that the wave or ray is vibrating back and forth in every direction within the limits of a circle.

Waves of light pass through any transparent medium, which may be air, glass, water, celluloid, amber, or any other substance through which we can see. As long as light travels in the same substance or medium, it goes forward in a straight line, but as soon as it strikes the surface of a different medium, it is deflected or bent at a slight angle, depending upon the nature of the substance, and does not bend again until it encounters another medium. This is called the rectilinear propagation of light, which simply means, as before stated, that in any particular medium—whether air, water or glass, light always travels in straight lines.

The principal sources of light are from objects heated to a high temperature. The most common source of light is, of course, the sun, which is a heavenly body incandescently hot. In the arc light, the light is emitted by the carbon tips heated to incandescency by the passing of the electric current. Incandescent lights give forth light because their filaments are heated by the passing of the electric current. Ordinary kerosene lamp flames are luminous, because of the hot particles of carbon in the flame. Bunsen burners and alcohol lamps give forth very little light, because there are no solid particles in their flames to be heated to incandescency. There are exceptions to this rule of light being accompanied by heat, such as the glow of the glow-worm, phosphorescence of phosphorus, and light from some kinds of electric discharges. These exceptions are not very well understood and are seldom of any use in connection with photography.

In the Cooper-Hewitt lamp, vapor of mercury is rendered incandescent by the passing of the electric current. A luminous



*(Courtesy of the American Film Company)*

Hallway set constructed entirely of new lumber and materials. The construction is as carefully planned and as complete in detail as that used in a modern home. The woodwork is grained and painted and the walls papered, all in soft shades which will bring out the detail without reflecting light. Bright, glossy surfaces are avoided as far as practicable in order to eliminate halation.

body, that is, anything giving forth light, sends forth the light in all directions from itself, just as a pebble dropped on the surface of quiet water sends out ripples which leave the place where the pebble dropped in ever-widening circles. Do not become confused by the idea of the circle. Remember that any point on the crest of any of these ripples or waves has come

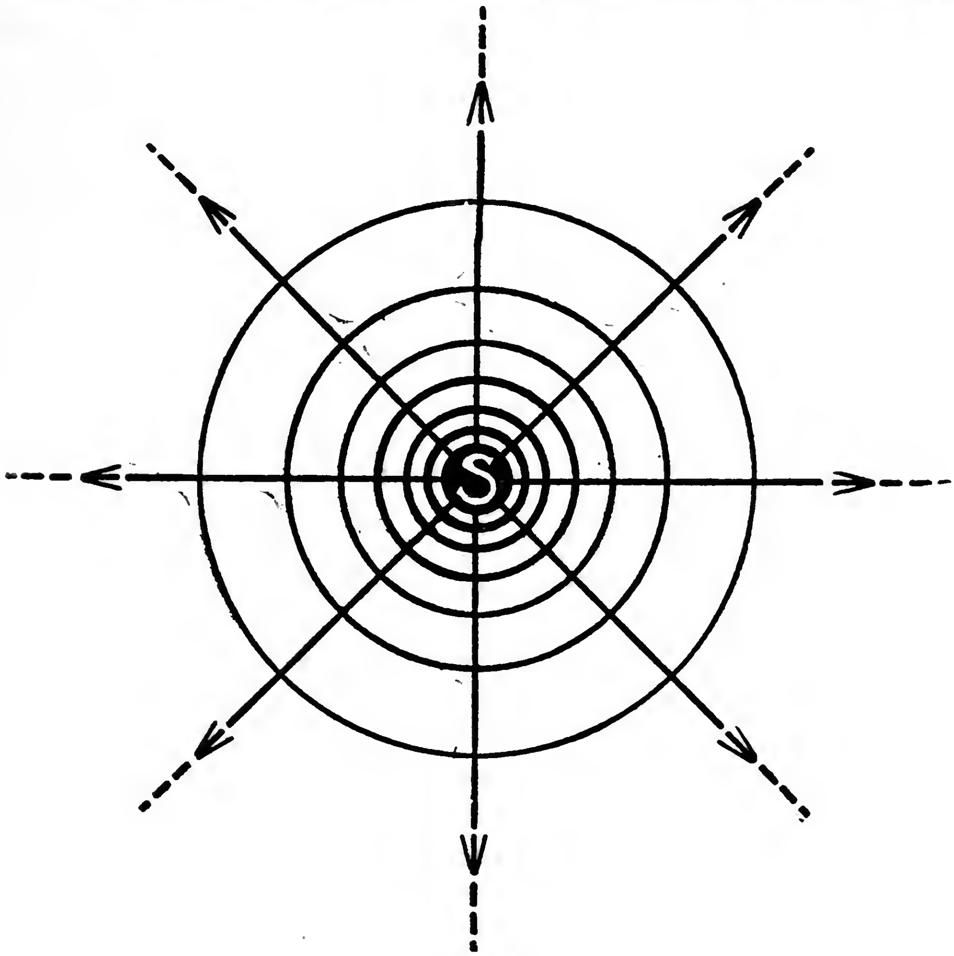



Fig. 3.

**This diagram roughly illustrates how a luminous point S radiates light outwardly in every direction like the radii of a sphere, in this case the figure represents a cross-section of such a sphere.**

outward from the pebble in a straight line. In a similar way, light waves move out in straight lines from their point of origin, not only in one plane, as the ripples do from the surface of the water, but in every direction. (Fig. 3.)

The velocity at which light travels is 186,000 miles per second; that is, nearly eight times the distance around the earth in one second. What increases the heat in a light source, increases the amount of light from that source, so by increasing the amount of an electric light current or energy through an electric arc light, its brightness is increased.

The size of the waves or vibrations of light varies as do the size of the ripples in a pond when stones of different size have been thrown in, but no matter what size these vibrations possess, they move forward at the same speed or velocity. The ether waves produced by a luminous body vary from 20,000,000,000,000 to 40,000,000,000,000,000 waves per second, and the wave length in ether accordingly varies from one 3,250,000th of an inch to about one 1,675th of an inch. Light waves, as they travel through ether, are all alike in every respect except that of size, and in that respect, they differ only in wave length and amplitude of vibration.

In figure one, the distance from A to B represents a ray of light traveling in the direction indicated by the arrow. The curved line represents light waves. The distance from crest to crest of a wave is the wave length. The distance from the crest and in that respect, they differ only in wave length and amplitude of the vibration.

Light waves of different lengths produce different effects when they strike a solid body. Those of the greatest wave length give the sensation of red light; as the wave length shortens, the color changes to orange-red, then to orange, and so on through orange-yellow, yellow, yellow-green, green, greenish-blue, blue, blue-violet, and violet. Waves of shorter lengths than these cannot be seen by the eye at all, but they are still able to produce an effect upon a photographic plate. They are called ultra-violet waves, or actinic waves. There is no fixed line between actinic waves and visible waves; that is, between light which we can see and light which we cannot see, but which will have an effect upon a photographic plate, because most of the light, which we can see, also has an effect upon a photographic plate.

Actinic light simply means the light which has the strongest action upon a photographic plate, whether visible or not.

There are also light waves, which are so long that they are not visible, they are longer than the visible red rays and are called infra-red or heat waves.

The intensity of light refers to its brightness, for example, a sunshiny day possesses a more intense or brighter light (degree of illumination) than a cloudy day.

The intensity of light diminishes in proportion to the square of the distance from its source. For instance, let us refer to Figure No. 4, which represents light rays emanating from a small source, such as an arc lamp or the flame of a candle. Let the square A represent screen one foot square placed at a distance

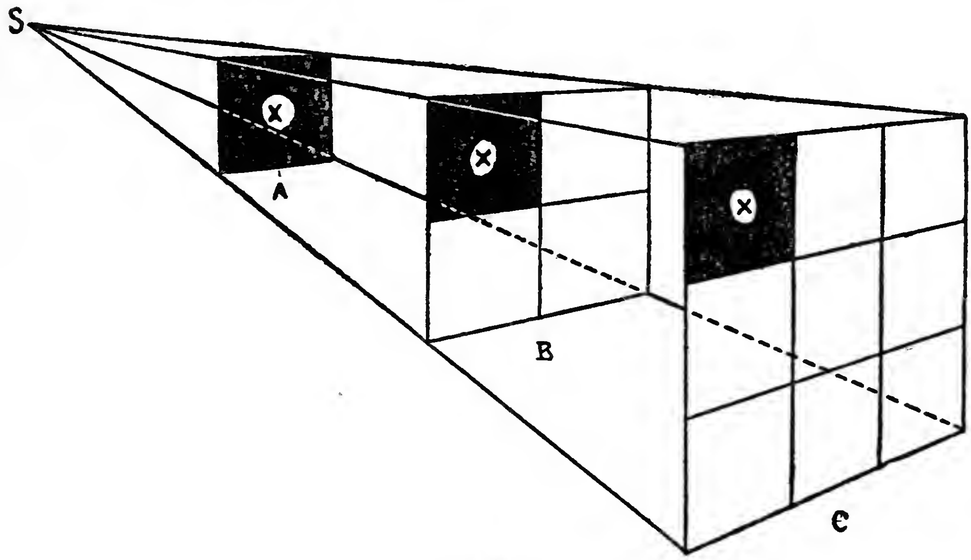



Fig. 4.

**The intensity of light falling upon a given area varies inversely as the square of the distance from which it is removed from the light source. The black squares marked X are the whole, one-fourth, and one-ninth, respectively, of the larger squares A, B and C. A is one foot, B, two feet and C, three feet away from the light source S. The black squares being of the same size will receive less light as they are removed from the arc light.**

of one foot from the light and the square B screen placed at a distance of two feet from the light. These two squares are in a line with the light, square A exactly shades square B. If we remove square A the same amount of light which fell upon square A will now fall upon square B. Square B is twice the diameter of square A, or four times its area. Since the same amount of light which fell upon square A covers a surface four times as great as twice the distance, it follows that the intensity of the light falling upon B is only one-fourth of the intensity of light falling upon A, or conversely, the intensity of the light falling upon A is four times the intensity of light on screen B.

This law of illumination must be taken into account very particularly where artificial illumination is used, for if it takes a cer-

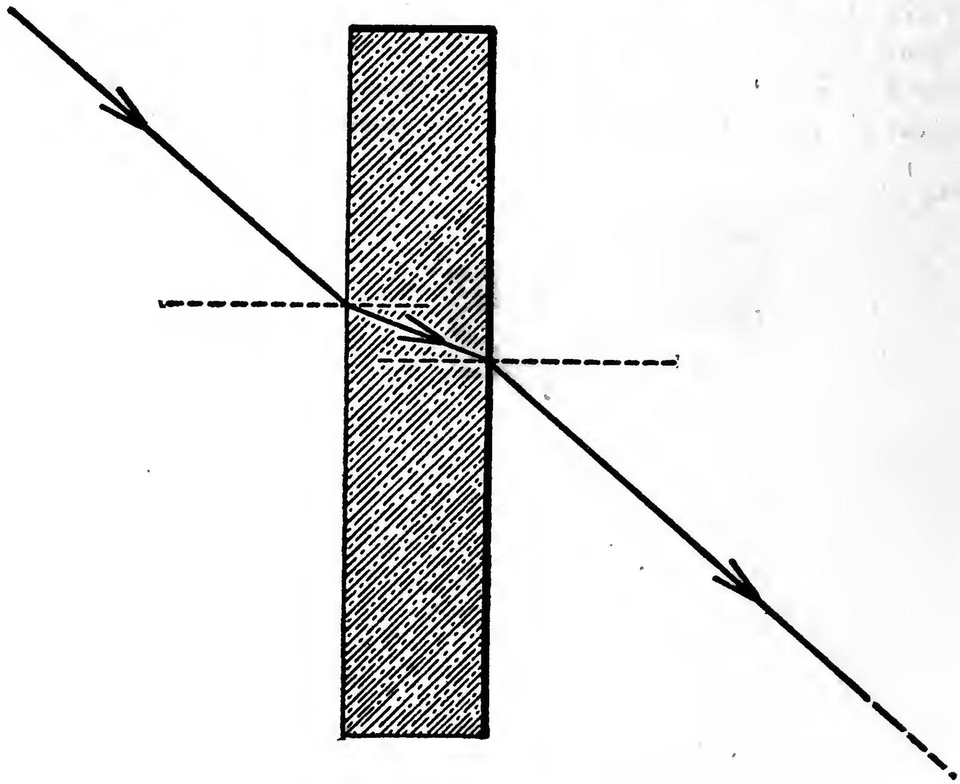


Fig. 5.

When a ray of light strikes another medium of greater or lesser density than the one it is leaving then, unless it strikes exactly perpendicular to the surface of the new medium, it will be bent or refracted. Figure 5 shows a ray passing through a block of glass and suffering two refractions, one upon entering and one upon leaving. In this case the two surfaces being parallel, the first refraction is neutralized by the second and the light ray continues in its original direction slightly displaced but parallel to its original course.

tain number of lights to illuminate a certain small set properly, it will require four times as many lights to properly illuminate a set which is only twice as large. Therefore, it is practically impossible to artificially illuminate a very large set since the limit of the practical number of artificial lights is soon reached.

When light strikes an object, part of it is reflected or thrown

*(Courtesy of the American Film Company)*

THE ASSISTANT CAMERAMAN HOLDS UP A SLATE WITH A NUMBER ON IT AT THE END OF EACH SCENE.

back. It is because of this fact that we are enabled to see objects and to photograph them. The kind or quality of light reflected enables one to photograph objects. The violet light is quite active photographically, while the other end of the spectrum, red, is not.

If the object reflects all blue or violet the photographic sensitive surface will be strongly affected and the object easily photographed, but if the object reflects yellow and red waves only, the sensitive surface will be only feebly affected.

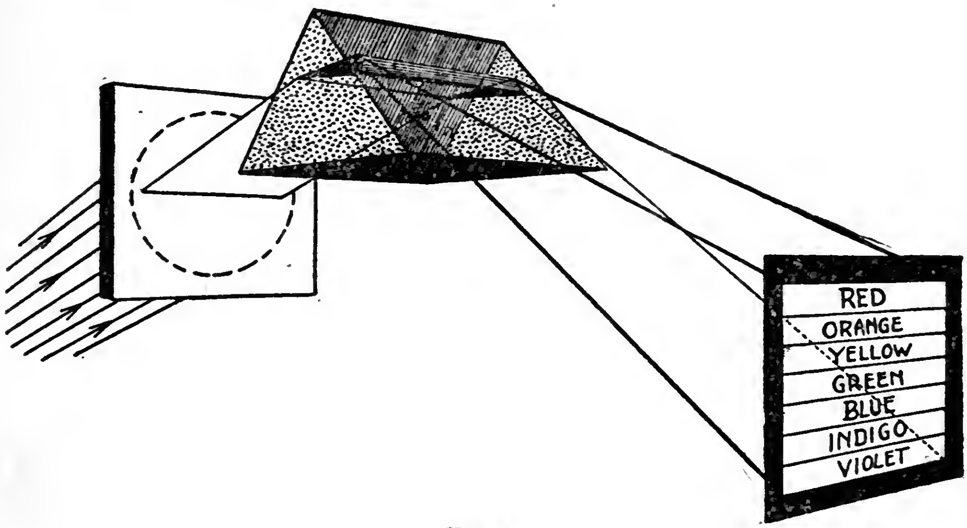



Fig. 6.

Production of the spectrum by means of a prism.

It is for this reason that photographic operations are carried on in dark rooms which are illuminated only by faint red or orange light. All dark room lights should be carefully tested by exposing a sample of the most sensitive surface that is to be worked under the light in question for a greater period of time than such sample would be exposed under any ordinary working conditions. If on development the sample shows traces of fog, the light should be changed or its intensity decreased. When a certain color of light predominates, the unaided eye is not able to distinguish a contamination of another color, consequently wherever possible it is very desirable to make a spectroscopic examination of the light passed by screens used for dark room illumination.

From this it will be seen that much depends upon the quality of light reflected in photographic work.

Refraction—When light passes from one medium to another of different density it is refracted or bent as shown in diagram No. 5. The different colored rays being refracted or bent in different degrees. Upon this principle depends the construction of lenses.

Dispersion is shown in diagram No. 6 that is, light in passing through a glass prism is separated into its component parts, and

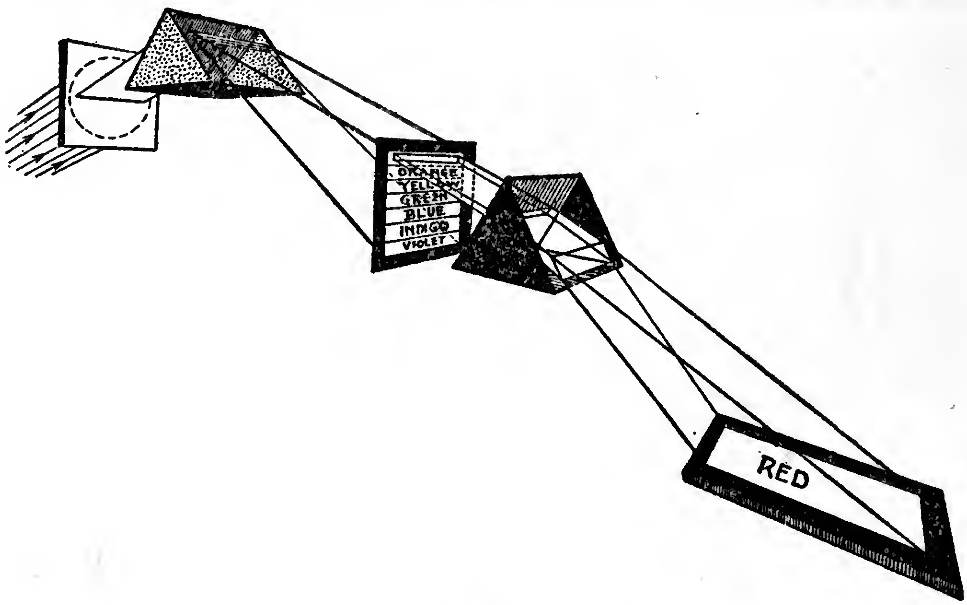



Fig. 7.

Showing the elementary character of a primary color. Primary colors cannot be further resolved into other colors.

in case of white light into the spectrum colors violet, indigo, blue, green, yellow, orange and red.

Absorption—When light falls on an object which neither reflects, refracts nor transmits, the light is said to be absorbed. No known substance is an absolute absorber of light; that is, an absolute non-reflector. A flat or matte black surface comes the nearest to being a total absorber of light, but it is not possible to paint an object so black but what sufficient light will be reflected from it to reveal its details when brilliantly illuminated. Thus we see that what we call blackness is not caused by no light reaching the eye but when very little does. The blackest object looks gray in comparison to what is called Chevreul's black, which is the darkness of the mouth of a dark cavern or a hole in a large box lined with black velvet.

If the object reflects only red all the other colors are absorbed; if only yellow is reflected, then all others are absorbed. Again, if we use, as our incident light, any particular color of light

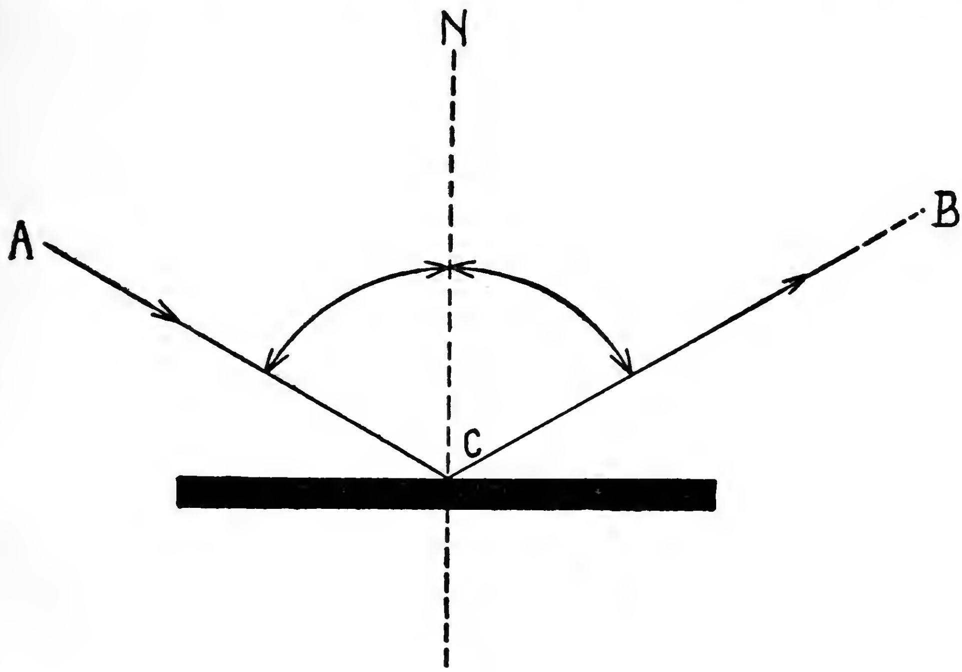



Fig. 8.

When light strikes a smooth reflecting surface such as a mirror or a pool of still water it is reflected back at the same angle at which it strikes or in more scientific terms the angle of reflection N, C, B in figure 8 is equal to the angle of incidence A, C, N, both angles being measured from a line perpendicular to the reflecting surface at the point where the reflection takes place. These two angles always lie in the same plane with the perpendicular line which is always at right angles to the reflecting surface.

which happens to be wholly absorbed by the object, that object will appear black; if, for example, we look at a yellow and a blue flower by the yellow flame of a spirit lamp with common salt in the wick, the yellow flower appears distinctly yellow, for it does not absorb yellow light on reflection, but the blue flower looks black, for it absorbs all the yellow light and reflects none of it.

We have briefly discussed four qualities of light. The entire science of optics is embraced under these four sub-heads and the better we understand these properties of light the more intelligently will we be able to know how to illuminate a scene and what lenses to use, in order to obtain any photographic result that we wish.

We have already found that light is propagated outwardly in straight lines in every direction from a luminous object. When it strikes a smooth reflecting surface, such as a mirror or a pool of still water, it is reflected back from the reflecting surface at the same angle at which it strikes, or in more scientific terms, the angle of reflection is equal to the angle of incidence, as shown in Figure 8. As we have become accustomed to visualizing objects as being in a straight line before us, since light always travels in straight lines, when we look into a mirror we do not see the

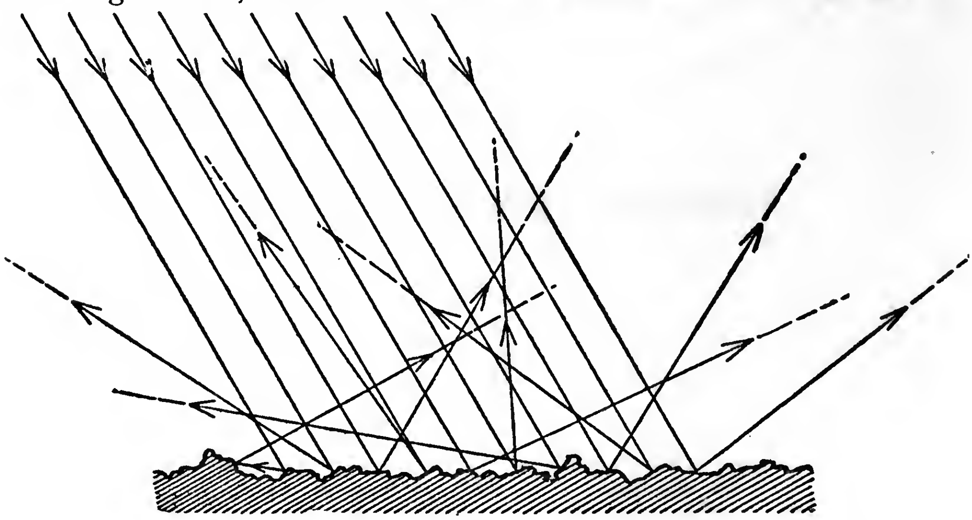


Fig. 9
Reflection of light from an irregular surface.

mirror itself but the image which it reflects and the reflected image appears to be behind or beyond the mirror, since our habit of sight perceives the reflected object in that direction. If, however, the rays of light fall upon an object which is not perfectly smooth, each tiny particle which composes its surface presents a different angle to the light rays than its neighbor, so that the light will be reflected at a different angle from each of these particles. This light reflected from the rough surface has thus had its direction broken so that it travels in many different directions. This is shown in exaggerated form in Figure No. 9.

*(Courtesy Robertson-Cole Productions)*

STUDIO USING ALL "HARD" OR ARC LIGHTS. OVERHEAD LIGHTING FROM DOMES. IN THIS SET THE DOMES SERVE A DOUBLE PURPOSE BEING CAMOUFLAGED WITH OIL LAMPS FROM WHICH THE LIGHT APPEARS TO COME.

Such light is called a diffused light, thus, on a cloudy or hazy day, the light of the sun is diffused by its many reflections and re-reflections from the particles of watery vapor in the atmosphere. On a clear day the direct rays of the sun cast a dark shadow when any object is interposed between the sun and any surface upon which its rays fall, but when the light is diffused the reflected rays from many directions fall beneath the object, since the object is not in line with these reflected rays, and illuminate the surface beneath the object and we are not able to distinguish any perceptible shadows.

Practically all interior illumination is diffused light, for we can only have direct illumination where the sun shines through a window or other opening. We find it necessary to diffuse the light in interior scenes in order to make them appear natural, for it is not yet possible in the majority of cases to obtain sufficient illumination in an actual interior to act upon a photographic film with sufficient intensity in the short time of the exposure necessary with the motion picture camera. We have to build our interior sets in a studio leaving them open to the light at the top, and generally upon two sides, thus allowing a flood of light to enter. If the stage is an open platform, or if the studio is not of ground or ribbed glass, which of itself diffuses the light, it becomes necessary to suspend screens of thin white cloth called diffusion or halation screens above the set, to break up and diffuse the direct rays of the sun.

We can all recall witnessing, even very recently, interior scenes taken in the direct sunlight where the pictures hung on the wall cast long oblique shadows and the characters, as they went through their actions on the screen, were each accompanied by a funereal silhouette which mocked every gesture in grotesque distortion upon the floor or wall. Happily, such scenes have now passed into the limbo of fading memories. When artificial lights are used, such as arc lamps, the light is diffused by ground or ribbed glass screens or with tracing cloth or similar material. The tubes of Cooper-Hewitt lights cover such an area that it is not usually necessary to use a screen for them, for the light, coming from so large an area covered by the tubes, is already sufficiently diffused.

When we produced the spectrum by passing a ray of light through a glass prism we found that the beam of light was bent or turned to one side by the glass; that is, the light was refracted. This refraction only takes place at the point of entrance between two mediums of different density. After being refracted at the surface the light continues to travel through the second medium in a straight line from the point of entry to the point where it emerges on the other side where a second refraction takes place, light again continuing to travel in a straight line. This angle of refraction varies according to the density of the medium in its relation to light and is always the same in the same medium, thus different kinds of glass and all transparent crystals and liquids have different angles of refraction. This angle of refraction is

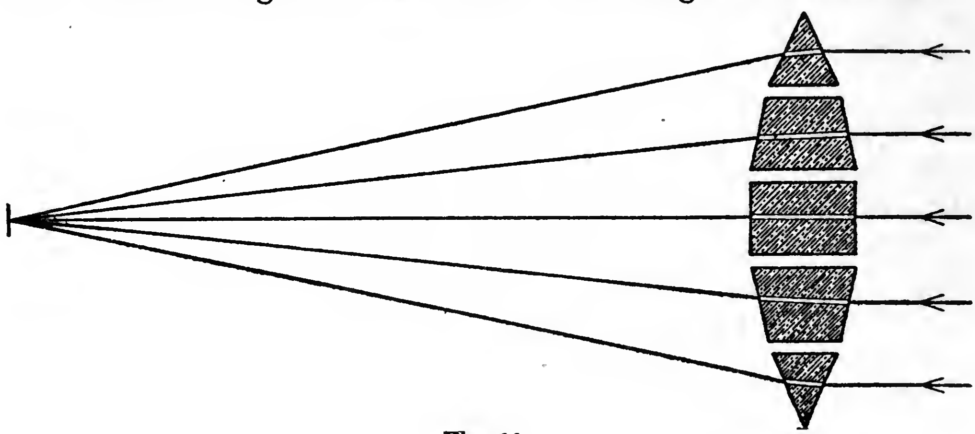


**Fig. 10.**

**Illustrating the relationship between lenses and prisms. If we consider a lens as consisting of innumerable small prisms built up around a common center this relationship will become apparent.**

called the index of refraction. These indexes of refraction have been measured by mathematicians who make calculations for manufacturers of lens and predict all of its properties before one has been made. Such calculations are, however, far beyond the scope or needs of any ordinary photographer.

In Figure No. 10, we have a point from which emanates rays of light. Suppose we take a number of prisms with varying angles as illustrated in the diagram, the angle of each being such that each ray which passes through each prism is refracted to the point so that each of these rays is again collected at this point. Let us now examine the line of prisms which we have thus placed. The central prisms have sides which are nearly parallel, which progress outward from the center, the angle increases until the two faces come together. We will now replace the line of prisms with a lens covering practically the same range as the prisms as in Figure No. 11. We find that the lens also gathers all of the rays as the prisms did and refracts them again to the same point so that we can consider the lens as a number of prisms rounded off into a single piece, or speaking still more exactly,

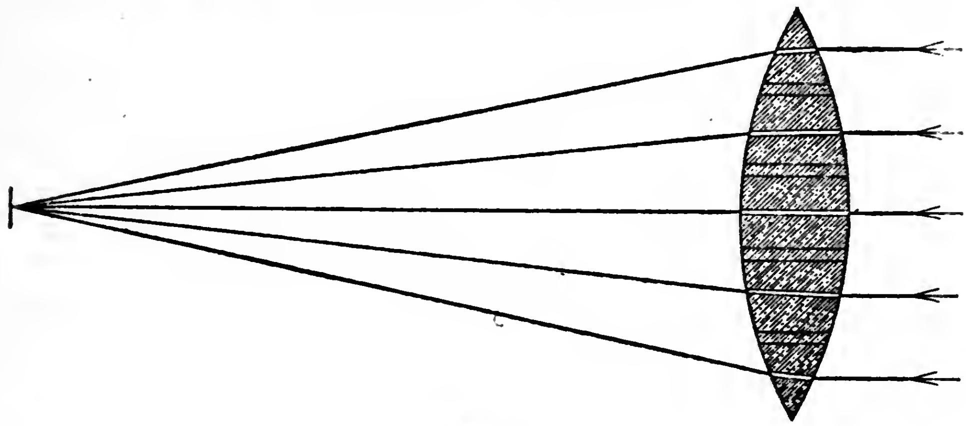


Fig. 11.

This is the same as Figure 10 with the proper curved surfaces substituted for the angular surface of the joined group of prisms.

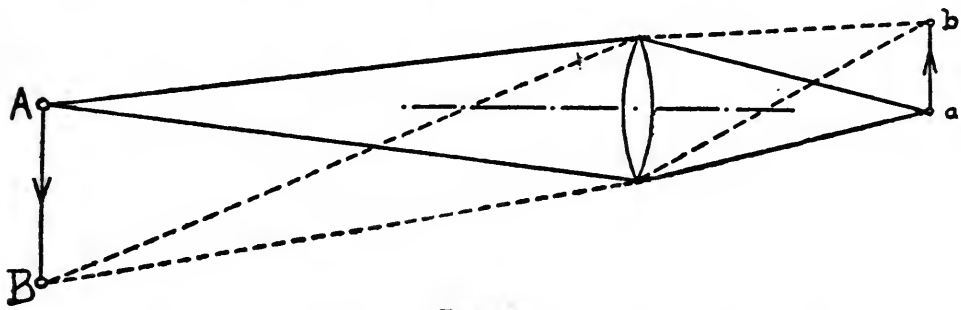



Fig. 12.

If we take two luminous points, A and B, we find that the lens will form images of these two points as a and b. The point A being on the principal axis of the lens its image will be formed at a, also on the principal axis any motion of B will cause a diametrically opposite motion in b.

that the lens is a continuation of an infinite number of prisms, the flat surfaces of which are too small for the eye to detect. This infinite number of surfaces, or points, we find ranges itself into the segment of a circle. This refraction of rays emanating from a point back to a point again is termed a "point of focus."

If we now take two luminous points at the same distance from the lens but separated a short distance from one another, as in Figure No. 12 we will find if we have a screen for the rays to fall upon, that the two points will be reproduced side by side in exact miniature on the screen, but that the point of illumination which is above the original point of illumination is reproduced below the point of the original point of focus of the first point. If we now move this screen closer to or farther away from the lens, we find that the point of light enlarges in a circle of illumination. This is termed the circle of confusion. By moving the screen back and forth we also find that there is only one position in which the points of illumination are perfectly reproduced. If, however, we now move one of these points of illumination to a much greater distance than the other, we find that while one is sharp and distinct the other forms a small circle of confusion and that when we move the screen so that the more distant one is in focus, that the other becomes a circle of confusion, or out of focus, as it is termed. If, however, we move the two points closer to one another, but still at different distances from the lens, we find that we can bring them both to a focus on the screen or rather, so nearly to a focus that the eye is not able to distinguish the difference in sharpness between the two. This difference of distance between the two points of illumination is called the depth of focus.

Let us now take the points of illumination, as in Fig. 13, with one of the points focused sharply. If now we interpose a piece of black cardboard, in which a small round hole has been cut, close to the lens so that this hole is near the center of the lens, we find that the brightness of the images is much decreased but that the image of the point which was out of focus is now much sharper. Let us refer again to our Fig. 13. Our images are not nearly so brilliant because much of the light which formerly came through the lens has been cut off by the piece of black cardboard; but as the cardboard has narrowed down the angle which the light ray takes from the lens to the focal plane, we have narrowed down, or made smaller, our circle of confusion.

Up to this point we have only considered light as it emanates from a point, but now we are ready to consider any object which may be reproduced by a lens as an image. In photography, practically all images that we have to consider are delineated or formed in one plane; that is, either upon the flat surface of a photographic plate or upon a film stretched flat or upon a piece of photographic paper, as in a photograph, or upon a screen in a moving picture theater, so that no matter by what means we

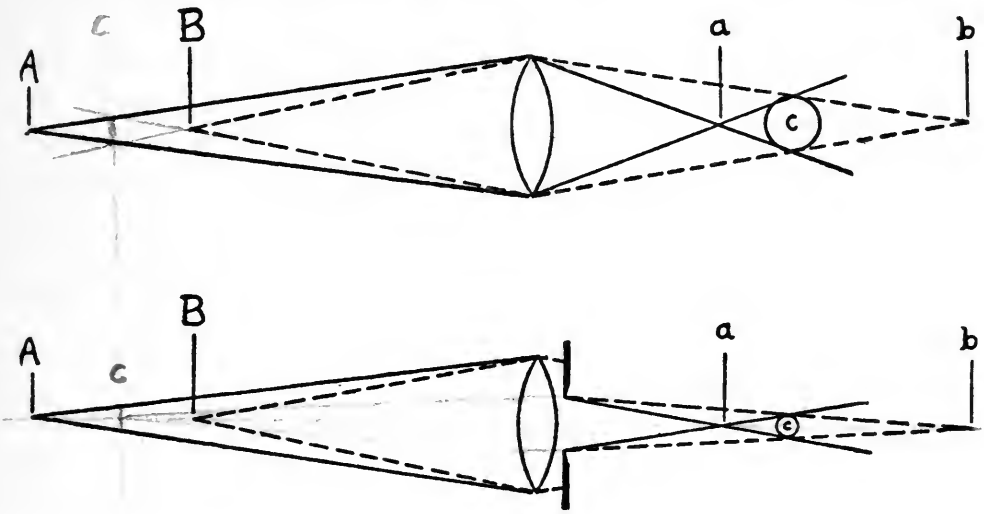



Fig. 13.

Let us take the points A and B in these two diagrams. In both the upper and lower diagrams the image of A will form in the plane a and that of B will form in the plane b. It is in these two planes that the sensitive surfaces should lie to render sharply the images of A or B as the case may be.

We desire to receive both of these images however on the plate at once and utilize the two following means for obtaining the result. First we compromise between the two planes a and b and place our plate in the plane "C." We do this because the circle of confusion at C, is common to both and is the smallest mean between the planes a and b. This compromise prepares us for better results in our 2d procedure. This consists of placing a diaphragm close to the lens. This diaphragm is a piece of black cardboard with a smooth, round hole in it and its function is to diminish the angle on the rays of light that represent the extremes of the cones of light which form the images a and b. This has the desired effect of reducing the size of the circles of confusion at C to an inappreciable size. This size depends on the distance between A and B and on the size of the hole in the diaphragm. A circle not greater than 1/100 inch is permissible in stills but for the cinema film one of 1/400 inch is about the limit of size.

produce a photographic image it is practically always done upon a flat surface. Let us for the purpose of our analysis, consider any object or any image as being composed of a collection of a vast number of small points of different degrees of illumination, placed beside each other forming an infinitely fine mosaic which delineates the object or image which we have under consideration. To make this point clearer, inspect very closely with the naked eye, or better still, with a small magnifying glass, any half-tone cut in this or any other book or paper and you will see that the entire picture is formed by small dots of varying sizes which make up the picture. In the same manner we may consider any object or image as consisting of an infinite number of small points not necessarily arranged in mechanical order as in a half-tone cut. This mechanical sequence in a half-tone is merely a method of surmounting certain mechanical difficulties in photo-mechanical

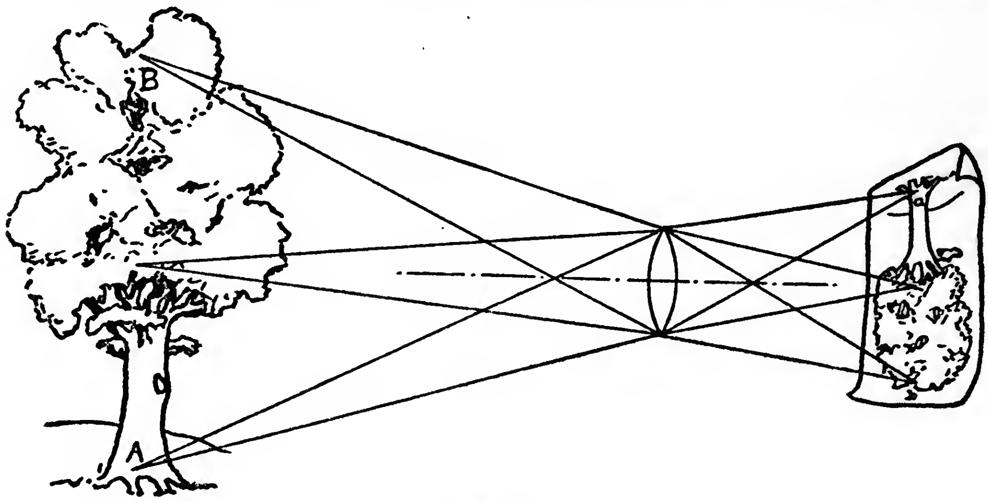



Fig. 14.
Production of an image by a lens.

reproduction, the size of the dot representing the intensity of illumination of that particular portion of the picture which it represents.

There are many other processes of photogravure too complicated for ordinary book production in which the dots are arranged in irregular order or in which the light intensity is registered by other means, such as the Mosstype, the Albertype and various photogelatine and lithographic processes.

We have already seen that all objects reflect a certain percentage of light. If by means of a lens we can focus the luminous points which delineate an object upon a flat surface, we must necessarily obtain an image of that object upon the focal plane, as in Fig. 14.

This image is always reversed and inverted; that is, like a mirror reflection turned upside down. By again referring to Fig. 14 we see the reason for this. All of the light rays emanating from A on the tree which strike the lens are condensed and brought to a focus at the point a in the image. Likewise,

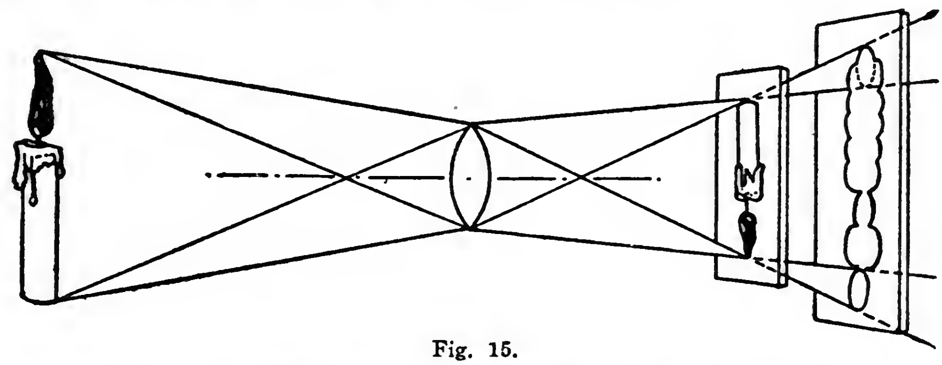


Fig. 15.

Indistinct image caused by overlapping circles of confusion.

all of the rays which strike the lens from the point B are focused at the point b in the image; in a like manner all of the other points on the surface of the tree are delineated on the screen without rendering the diagram too complicated by trying to reproduce the path of the light rays from all of the other points on the tree. If we move the screen a small distance in either

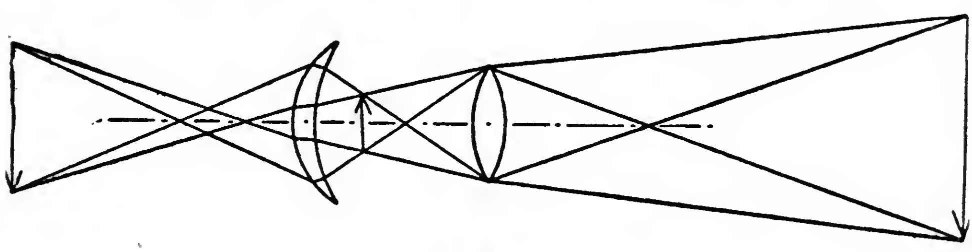


Fig. 16.

Double inversion by means of two lenses.

direction from the focal plane the image becomes blurred and indistinct, since our points of illumination then become overlapping circles of confusion, as in Fig. 15. The image ab in Fig. 14 is termed a real image, because it may be focused upon a screen and to distinguish it from certain other images which we will consider later, which can be seen but which cannot be focused upon a screen and which are termed virtual images. This image may be again focused by another lens which again inverts the image, as in Fig. 16.

In Fig. 17 we have a diagram of the ordinary telescope in which the real image has been twice enlarged, in order that the

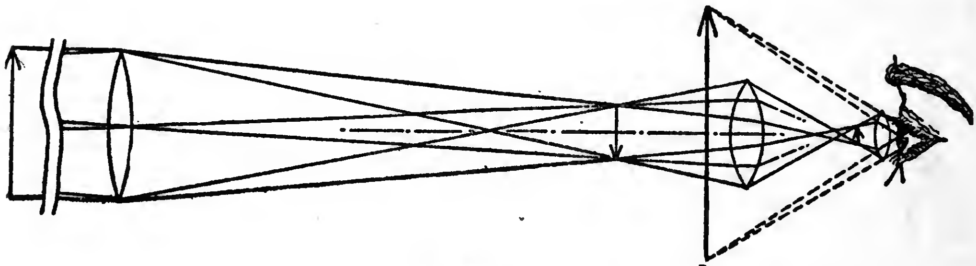


Fig. 17.

Diagram showing the path of the light rays in an ordinary telescope.

eye may see the enlarged image as an erect object. As it is of no consequence that the image be inverted in an astronomical telescope, it is provided with only two sets of lenses and the image is enlarged but once, the large lens, or objective, being made as

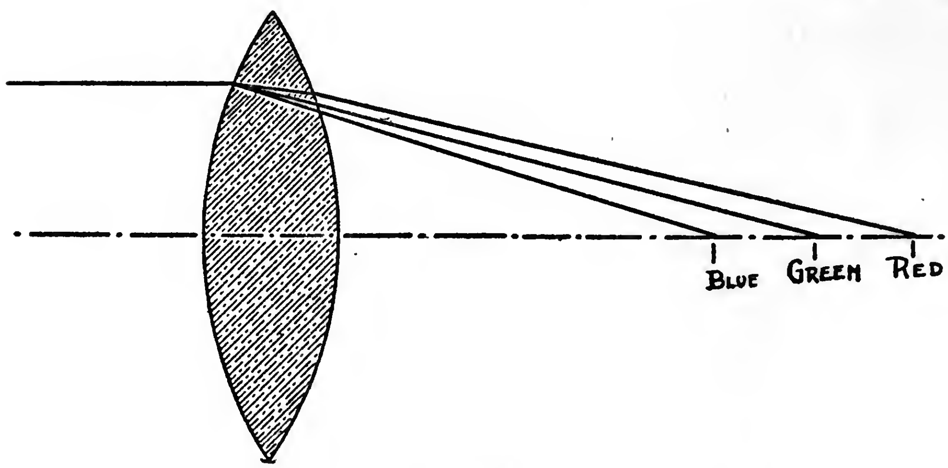
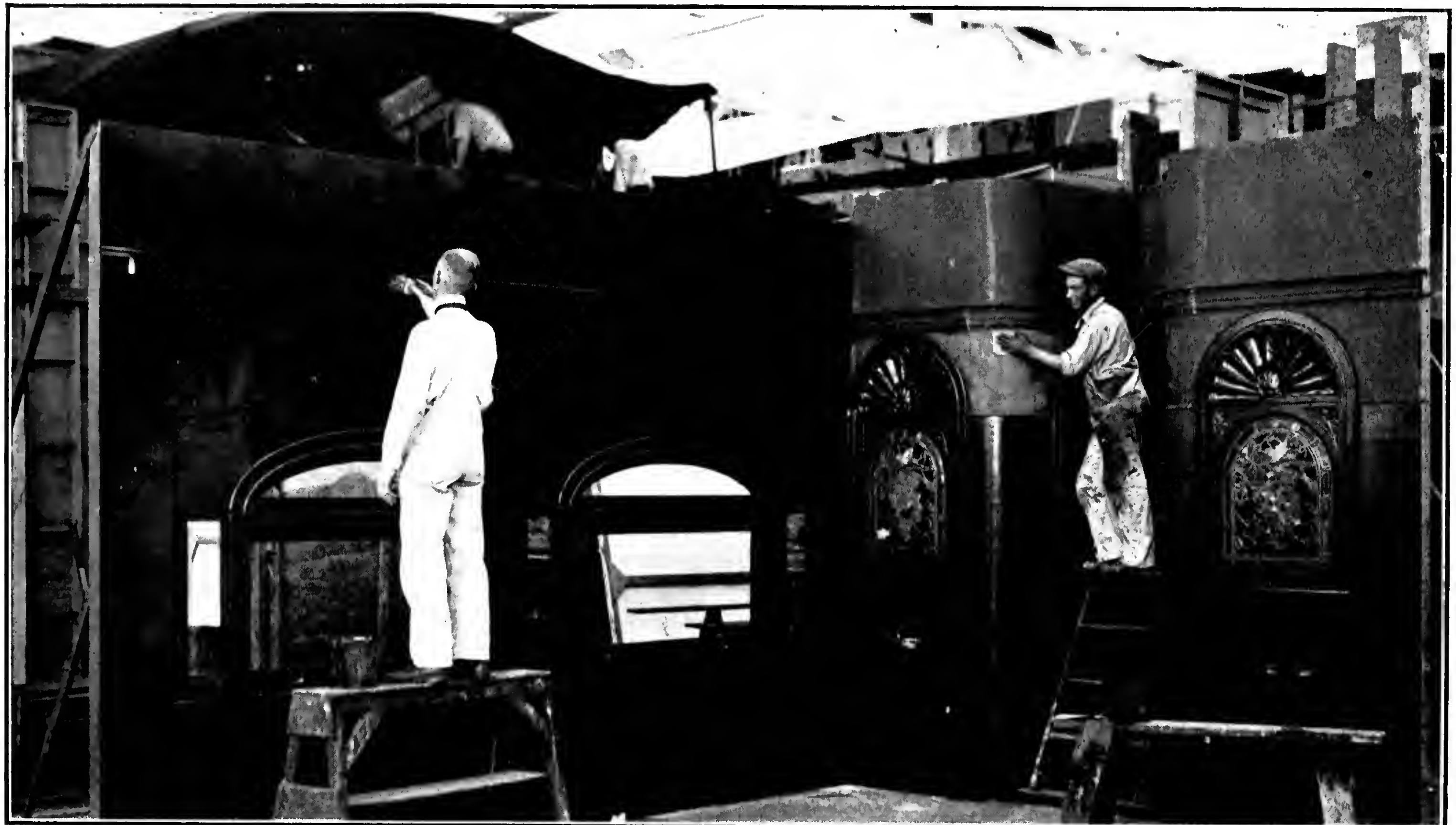



Fig. 18.

Light dispersion caused by an uncorrected lens.

large as possible in order to collect all of the possible light from dim and distant stars. The image formed by this large objective with great light collecting power being then examined by a magnifying eye-piece selected by the astronomer as being most suitable for whatever investigation he is conducting; large astronomical telescopes being provided with a number of eye-pieces



*(Courtesy of Ameriacn Studios)*

Buffet car used in set. The sandpapering, graining and painting being done by experts. The finished product is equal to any standard railway coach. The scenery is moved past the window while the camera grinds, giving the effect of a train in motion.

of various degrees of magnification. When photographs are taken of heavenly bodies the eye-pieces are removed and the photographic plate inserted in the tube of the telescope at the proper focal distance.

In our experiments with the prism, we learned that the glass of the prism had not only the power of refracting or bending the light, but also of dispersing or separating it into its component colors, and in our previous experiments with a single lens we will have noticed, if we have observed closely, that the images which we produced were fringed with prismatic color. In diagram 18

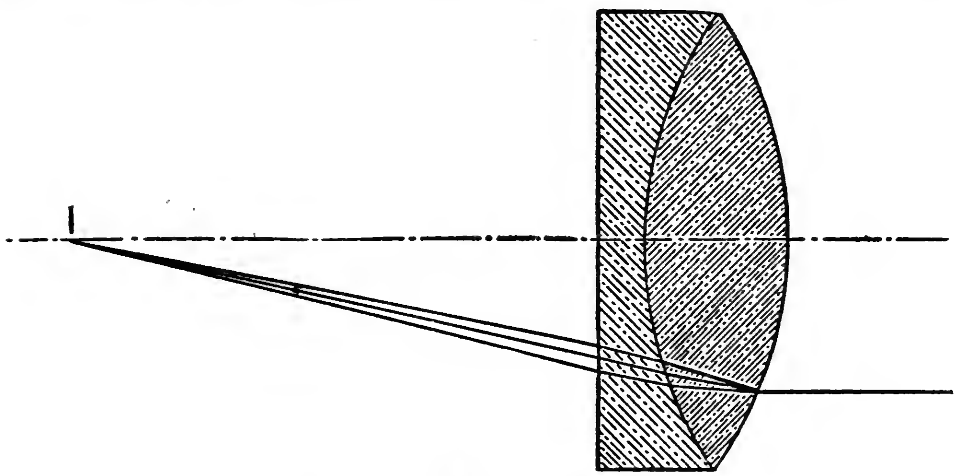


**Fig. 19.**

**Correction of dispersion by lens elements of different kinds of glass**

we see the reason for this, the blue and violet rays being refracted to a greater extent than those of the other end of the spectrum.

Very happily for photographic purposes, the light refracting power and the dispersive power of different kinds of glass are very different and not interdependent so that we are able to produce by cementing together, as in Fig. 19, or sometimes only mounting together in a metallic mount, lenses from certain combinations of different kinds of glass in which one kind counteracts the dispersive power of another kind and thus the different colors are brought to a focus at the same point. It would be very inconvenient to make a mathematical calculation and a very fine readjustment of a ground glass from the visual focus to the actinic focus of a lens every time we wished to take a photograph. This correction for visual and actinic focus is thus very important and is one of the principal reasons an ordinary magnifying lens is not suitable for making photographs.

It is an unfortunate fact that there are on the market today some makes of cinematographic lenses which are not fully corrected for visual and actinic focus. The writer was at one time compelled through force of necessity, to use such a lens, and it was only after making many tests to obtain a focusing scale or by focusing upon an object at a certain ratio of distance nearer the lens, that he was able to produce pictures of satisfactory sharpness with it. As it is never necessary to change the focal distance from infinity in astronomical photography, no attempt is made to correct telescopic objectives since, when actinic focus is once obtained, it is never necessary to change it.

The lens is the agent by which the light is directed to the right spot in forming the image depending upon the refraction of light. But before taking up the consideration of this important piece of apparatus for photographic work it will be necessary to explain what we mean by the "Optics of Photography" as distinguished from the optics of other sciences, such as those of the telescope and the microscope.

The chief distinctions are of two kinds: 1st, in photographic optics, the lens must be capable of transmitting and bringing to a focus in the same plane oblique and axial rays of light, as shown in Fig. 20.

The principal lens or objective of the telescope will not give a sharp image of an object if removed a slight degree from the axis or perfect squareness of position in relation to the line of light. Hence, the sharpness of the image produced by the objective of the telescope is confined to a small area close to the axis. The photographic lens, on the other hand, must be so constructed that it will give a sharp image of objects in front of the center of the lens and also of those that are situated to a certain extent on each side of the center.

2d. The photographic lens must also be so constructed that it will bring to a focus at the same spot the chemical and visual rays of light. If not corrected, the lens will act as a prism and separate the light into its component parts and produce the spectral or rainbow fringe around the edges of the image.

The violet or active end of the spectrum is brought to a focus close to the lens and the red at the greatest distance. The yellow, which is brightest visually, is also further from the lens than the active violet. In focusing visually, the plane of the yellow would be sharp, but in photographing the sensitive surface would have to occupy the plane of the violet. The result would be that the image of the object focused by the eye would be a blur in the photograph. The photographic lens must be so constructed that the image of the object will appear sharp and clearly defined to the eye, and be equally sharp as a result of the

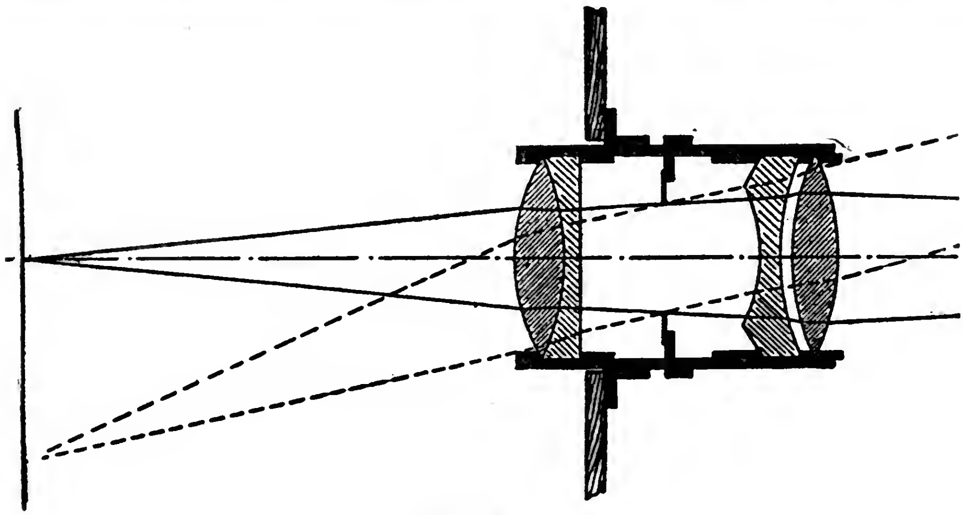


Fig. 20.

A cross section of a photographic objective, one of the combinations consisting of uncemented elements and the other of cemented lenses.

chemical rays, when it is developed upon the photographic plate. Such a coincidence of the chemical and visual rays does not exist in the telescope or the microscope, but only in the photographic lens. In the telescope and the microscope, which are constructed for visual work, it is not necessary.

To sum up these remarks it can be stated briefly that photographic lenses transmit oblique as well as axial rays and bring them to a focus in the same plane; and also bring the chemical and visual rays of light to a focus at the same spot.

This brings us to the consideration of the photographic lens and the principles which underlie its construction. By a lens is understood a piece of clear glass bounded by polished curved surfaces. The various forms of simple lenses are divided into two general classes:

| | | |
|---|---|---|
| Positive or Converging | 1st. | Double Convex. |
| | 2nd. | Plano Convex. |
| | 3rd. | Convexo-Concave. |
| Negative or Diverging | 1st. | Double Concave. |
| | 2nd. | Plano Concave. |
| | 3rd. | Concavo-Convex. |

The first are thickest in the center, while the second are thinnest in the center.

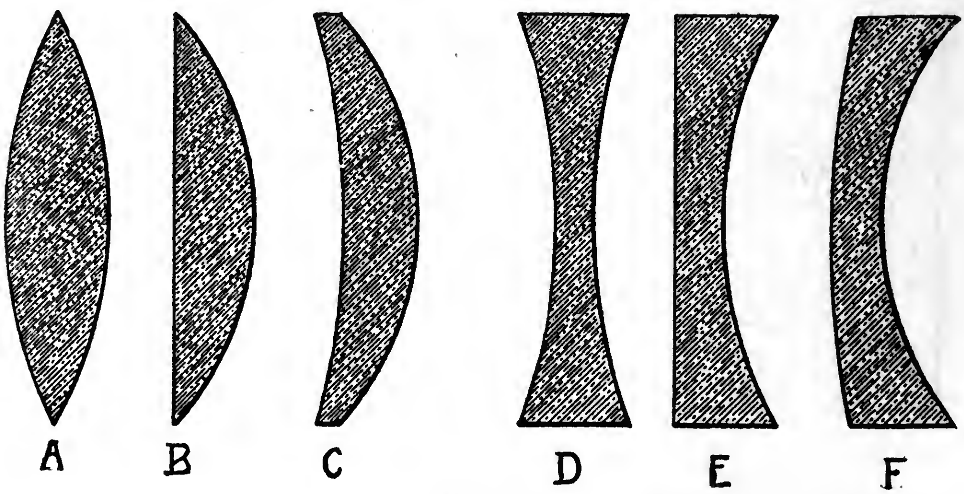


Fig. 21.

A, B, C, positive or converging lenses. D, E, F, negative or diverging lenses. A, double convex; B, plano-convex; C, convexo-concave or meniscus; D, double concave; E, plano-concave; F, concavo-convex.

These simple forms may be made up of one single piece of glass or they may be composed of several cemented together, as will be seen later. Diagram 21, illustrates these forms of lenses.

All lenses, whether considered singly or in combination, have the following properties:

1. Principal axis.
2. Optical center.
3. Principal and conjugate foci.
4. Nodal points.

1st. Principal axis of a lens is a line passing through the thickest part of positive lenses and thinnest part of negative

*(Courtesy of the Universal Film Company)*

NOTE USE OF BOTH SUN AND ARTIFICIAL LIGHT.

lenses, perpendicular to the surfaces of the lens, as in diagrams No. 22 and No. 23.

2d. The optical center of a lens is the point from which focal measurements are made. This does not refer to a photographic objective which (in other than single view lenses) is a combination of lenses and quite another matter for the reason that a combination may have its optical center at a number of places according to the circumstances under which it is employed. The

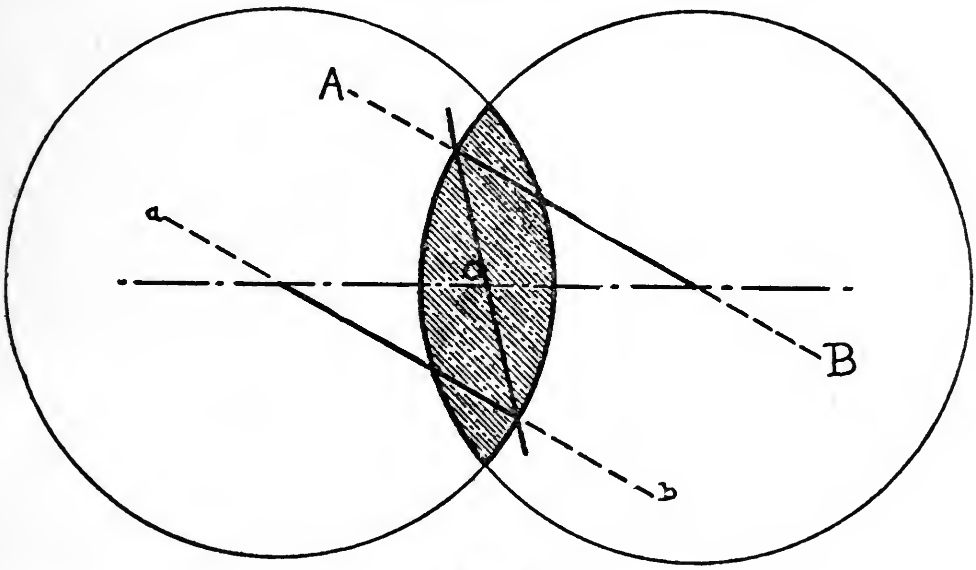



Fig. 22.

Nodal point within the lens.

positive optical center of a lens is determined by its form as follows and shown in diagrams No. 22 and No. 23.

Draw two parallel radii AB and ab one from each center of curvature, and both inclined to principal axis; then connect the two points B and b at which they touch the curved surfaces of lens. The point O, at which the line connecting B and b cuts the principal axis, is the optical center. In most cases the optical centre is within the lens itself but in some cases as with telephoto combinations and single meniscus lenses it may be some distance outside the lens. Such an example is shown in Fig. 23.

3d. Conjugate foci. If a lens which has been carefully focused upon a distant object be then directed toward one comparatively near at hand, the nearer object will be found to be out of focus, necessitating the withdrawal of the ground glass from the lens before the image will assume its maximum sharpness. This establishes the fact that there exists a relation between the object that is focused, as regards its distance from the camera, and the focus of the lens. This relation is termed "conjugate foci." Foci is the plural of focus; conjugate means combined in pairs; kindred in meaning and origin. Conjugate foci are then the distances from the lens to the image and from the

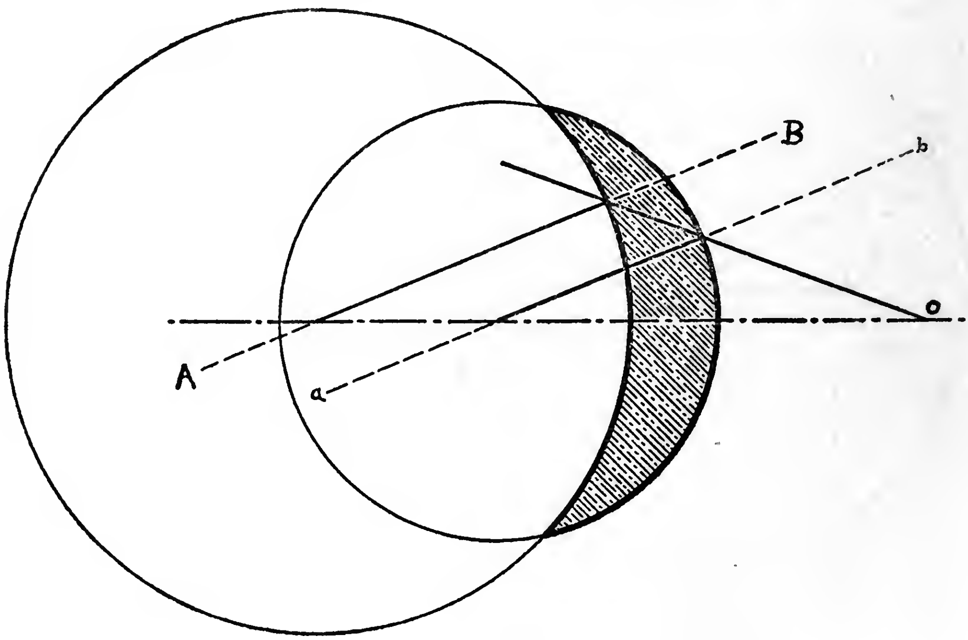
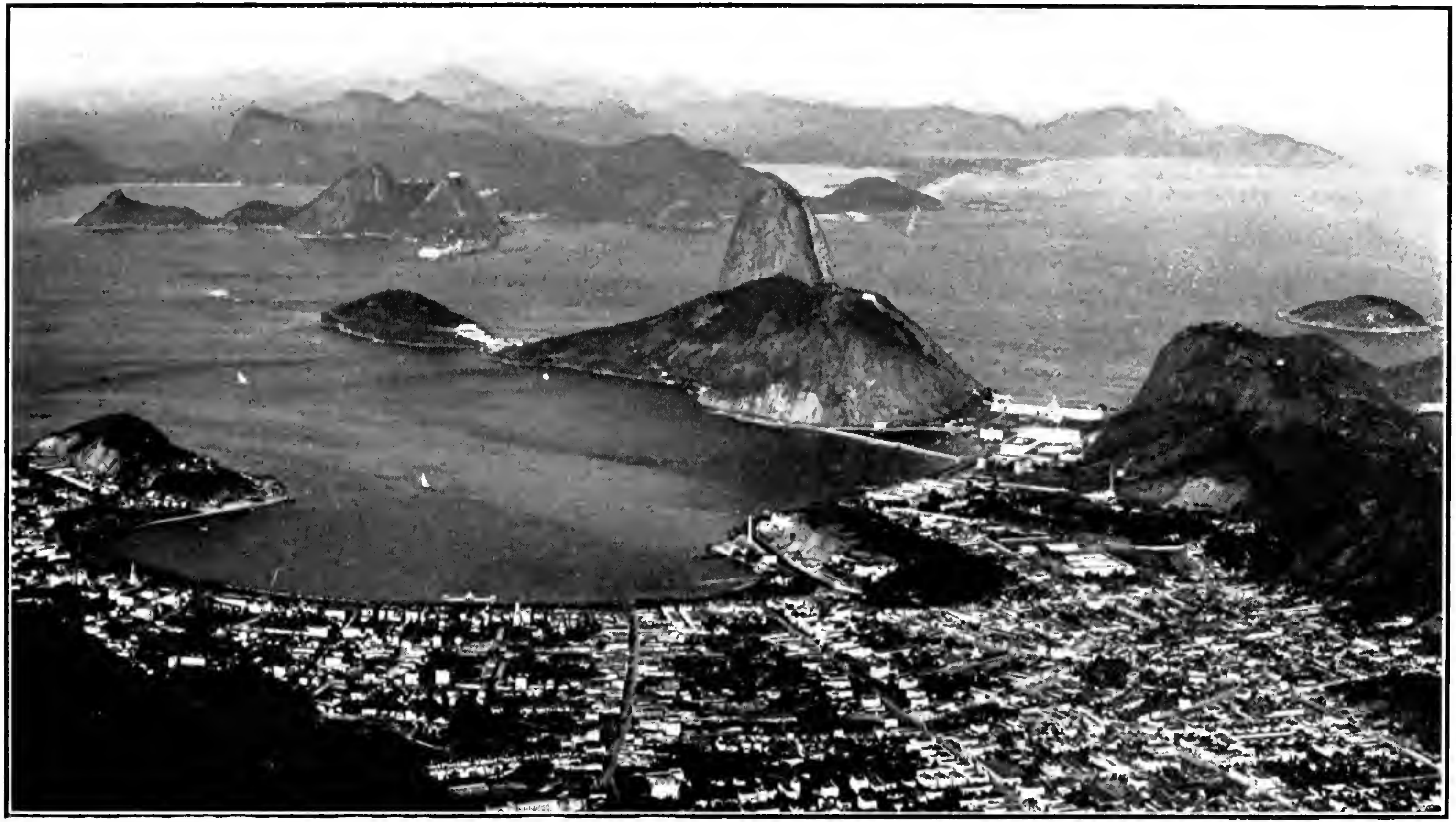



Fig. 23.

Nodal point outside the lens.

lens to the object. Hereafter we will speak of the distance between the lens and the object as the anterior or major conjugate, and that existing between the lens and the ground glass of the camera, as the posterior or minor conjugate focus. Parallel rays aa—that is, rays from a great distance—falling upon a lens come to a focus at f; but those from b, which may serve to represent any object ten or twenty yards distant, have their focus at c (Fig. 24). Then fo is the solar focus, bo and co are conjugate foci. The former of these is the anterior, and the latter the posterior conjugate. To facilitate reference, the lines indicating the conjugate foci are solid, while those relating to the solar focus



(*Courtesy of E. Fink, Graduate of N. Y. Institute of Photography*)

RIO DE JANEIRO—VIEW FROM SUMMIT OF CORCOVADO.

*(Courtesy of E. Fink, Graduate of N. Y. Institute of Photography)*

"NIGHT SCENE OF RIO DE JANIERO" FROM THE SUMMIT OF CORCOVADO.

are dotted. The points b and c are interchangeable; an object placed at either is sharp at the other.

Rule for Conjugate Foci. Now for every position of the object there is a certain position of the camera, and these two distances, the distance of the object from the lens and of the lens from the plate, are called conjugate foci.


Fig. 24.
Conjugate foci.

A very simple mathematical rule connects the distance from lens to object (D) the distance from lens to plate (d) and the enlargement or reduction of the object (i.e., the number of times a given line in the object is larger or smaller in the image). Note the word line, because some prefer to calculate reduction

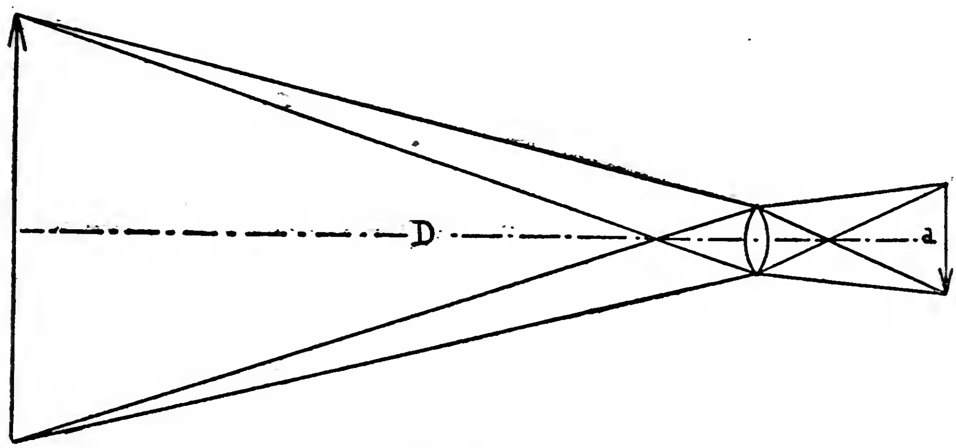



Fig. 25.
Determination of Conjugate foci.

and enlargement on the basis of area, which introduces different conditions.

Let F be the focal length of the lens and r the ratios of enlargement or reduction.

Then the distance d is equal to F plus F divided by r. Expressed more shortly:

$$d = F \text{ plus } \frac{F}{r}.$$

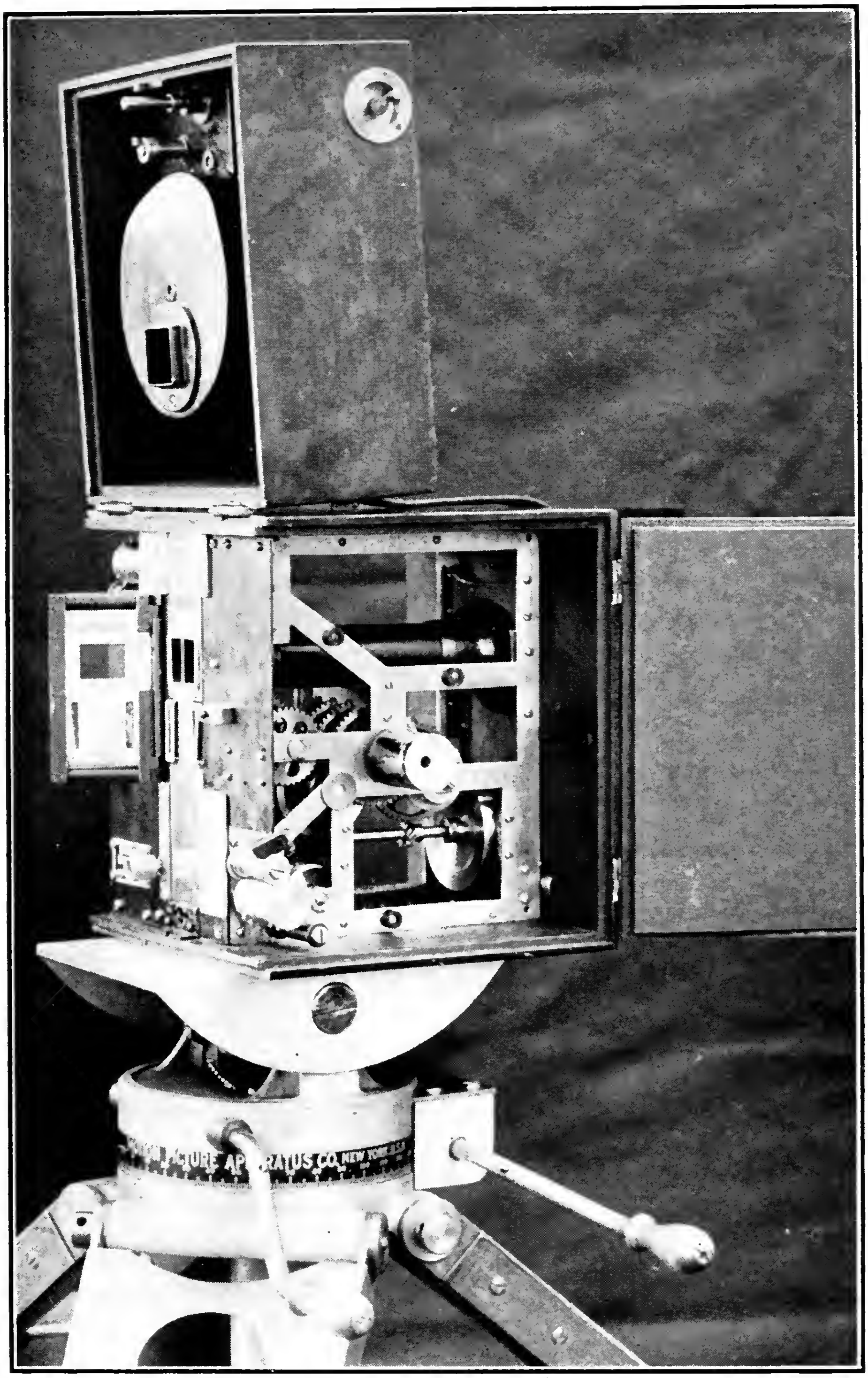
On the other hand, D equals F plus F multiplied by r, or

$$D = F \text{ plus } F \times r.$$

An example will show how simple this rule is. Suppose one wants to reduce a picture so that a twelve-inch line becomes three inches—i. e., $r = 4$.

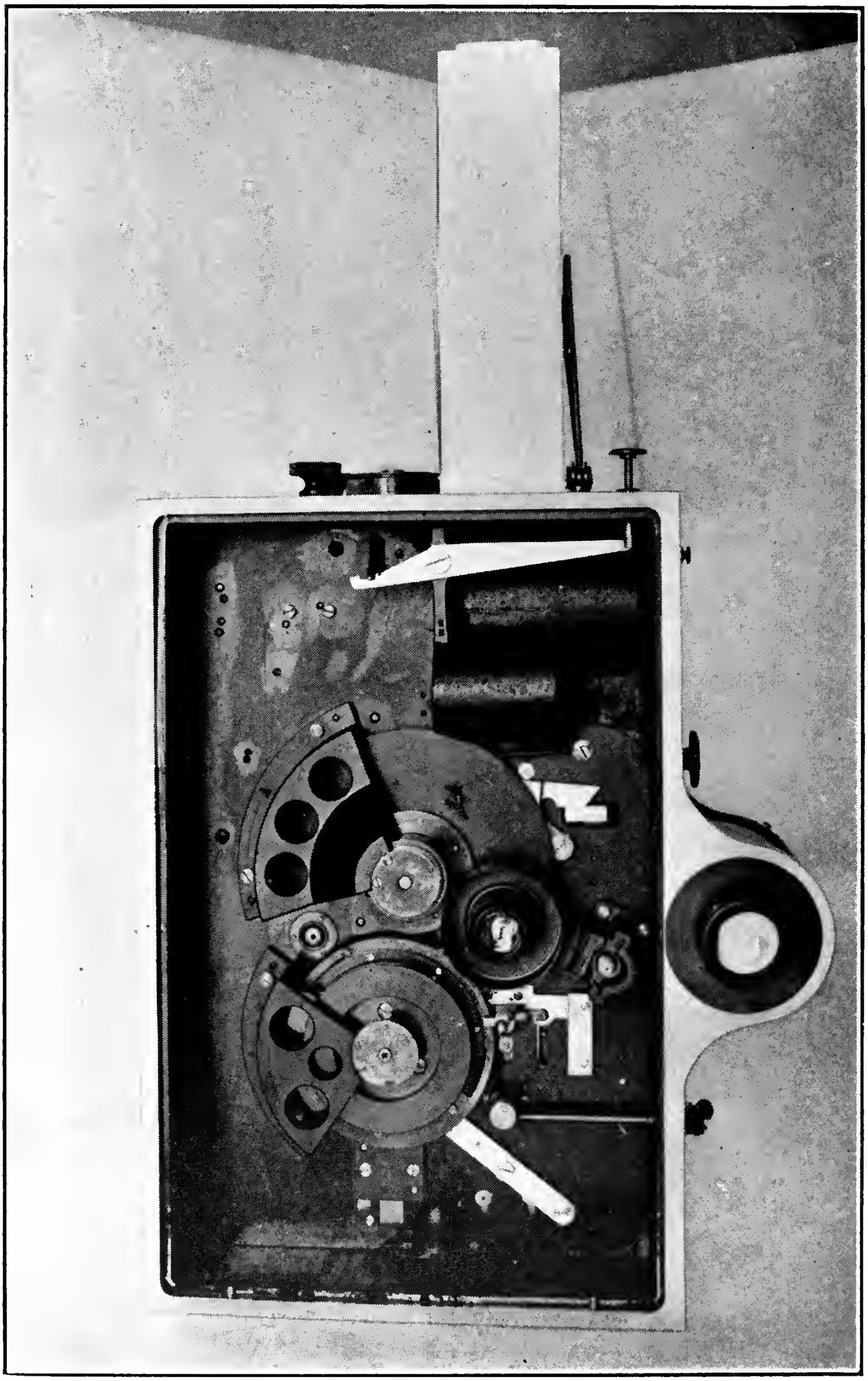
If a six-inch lens is being used, d (camera extension) $= 6$ plus $6/4 = 6$ plus $1\frac{1}{2} = 7\frac{1}{2}$ inches, and $D = 6$ plus $6 \times 4 = 6$ plus $24 = 30$ inches.

Bear two other things in mind which will help to use this formula: (1) Positions of image and object are reversible. If we were enlarging 3 inches to 12 with a 6-inch lens we should place the lens and negative $7\frac{1}{2}$ inches apart and the paper 30 inches apart. (2) The smaller conjugate is just r times the larger, e.g., $7\frac{1}{2} \times 4 = 30$. This is always the case, and is useful as a check on calculation.



(*Photo by U. S. Signal Corps School of Photography*)

An American-made camera copied after the French De Brie. The De Brie is the most compact of any model of Professional camera.



*(Courtesy of Wilart Instrument Company)*

This camera is extensively used in our school because of the various modern devices embodied therein.

## CHAPTER IV

# THE MOTION PICTURE CAMERA

LONG before motion pictures were dreamed of, philosophers and medical men were conscious of persistency of vision. They knew from their experiences and the experiences of others, if they looked at a bright object, such as the sun or a lighted lamp and turned their eyes to a dark corner the image, or at least a bright spot, would remain before their eyes for a few moments. The brain retained the illumination that the eye had sent to it for a few moments. Experiments proved that this persistency of vision did not occur in the retina of the eye. Close inspection of the retina showed that the picture projected thereon by the lens of the eye vanished the instant the entering ray was cut off. Therefore scientists stated definitely that the illusion was centered in the brain. No further explanation has been made.

No human being or animal has ever been known to be without this peculiar trait. No human being or animal has been known to lose this persistency of vision. If a mortal could be found who did not possess it, when looking at moving pictures, he would see not pictures in motion, but a number of "still" or inanimate pictures following one another very rapidly, each one perfectly still for about a sixteenth of a second.

Motion pictures are simply a number of snapshots run before a strong illuminating light and projected, by means of a powerful lens, upon a white screen or surface. Each picture is arranged so that it will stop for a fraction of a second and then move on, succeeded by another slightly different in appearance. The brain retains the image of the first picture and when the image of the second is telegraphed to it, by the sense of sight, the two blend and overlap and the spectator imagines he has seen but one image.

The camera in which the pictures are taken is similar to the projecting apparatus but instead of the light rays being emitted from the machine, as in the case of the projecting machine, they are gathered in or admitted through the lens. The rays fall upon a long strip of sensitized film, the same as that used in small hand cameras, made into a continuous roll which is fed past the lens intermittently at the rate of sixteen exposures a second. A revolving shutter is used in both camera and projector to cut off the light while the film is moving and a new section is being drawn into position before the lens.

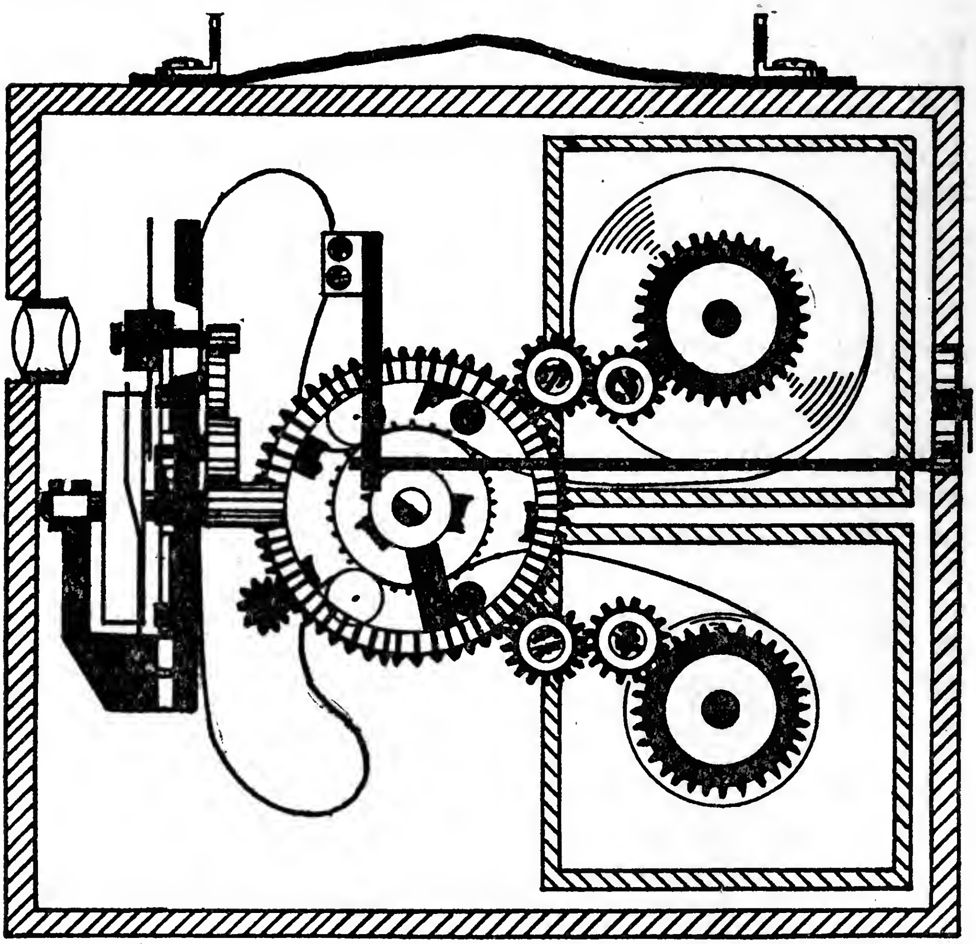


Diagram of the mechanism of the Universal Camera. A single sprocket camera with harmonic cam movement.

The motion picture camera is similar to the ordinary camera with the exception that it is provided with a mechanism for making exposures in rapid succession on a ribbon of film. Sixteen pictures per second has been adopted as the standard speed for taking and projecting motion pictures. This rate was adopted after a long series of experiments to ascertain the least number of pictures necessary to produce upon the screen a moving picture which would not offend the eye by the flicker or pulsation due to the intermittent succession of light and darkness which produces the illusion of motion.

If the number of pictures thrown upon the screen is less than sixteen per second, the persistency of vision is not sufficient to carry the impression of light over the intervening period of darkness. Although the eye may not be able to distinguish that the light is completely cut off while the next succeeding picture is being drawn into place, there is an unpleasant pulsation commonly called "flicker," which is very fatiguing and annoying. By increasing the number of alternate dark and light periods per second the persistency of vision is able to bridge the gap between the successive periods of light thrown on the screen. As the flashes increase in their rapidity, they gradually merge into a sensation of continuous light upon the screen without perceptible pulsation or flicker.

At sixteen pictures per second flicker is very perceptible so that many of the first cameras made were constructed to take many more than sixteen pictures per second. Some of them made as many as sixty-four exposures and used a film four times the area of the present standard. With the small returns obtainable from the exhibition of motion picture films in those days, this rendered the expense of taking motion pictures almost prohibitive. The present narrow width of film was adopted to cut down expense.

It was also found that it was not necessary to take so many pictures to produce a satisfactory illusion of motion. However, flicker is unpleasant when the number of light flashes is less than thirty per second. Sixteen pictures per second produce a satisfactory illusion of motion so instead of taking and projecting thirty or more pictures per second, a second blade or flicker blade was placed upon the shutter of the projection machine. This intercepted the light for an instant while the individual pictures stood still upon the screen so that there were two flashes of light for each picture.

Any camera mechanism which records the successive pictures upon the sensitive film is satisfactory—there is no need of a flicker blade except to make a perfect record for reproduction.

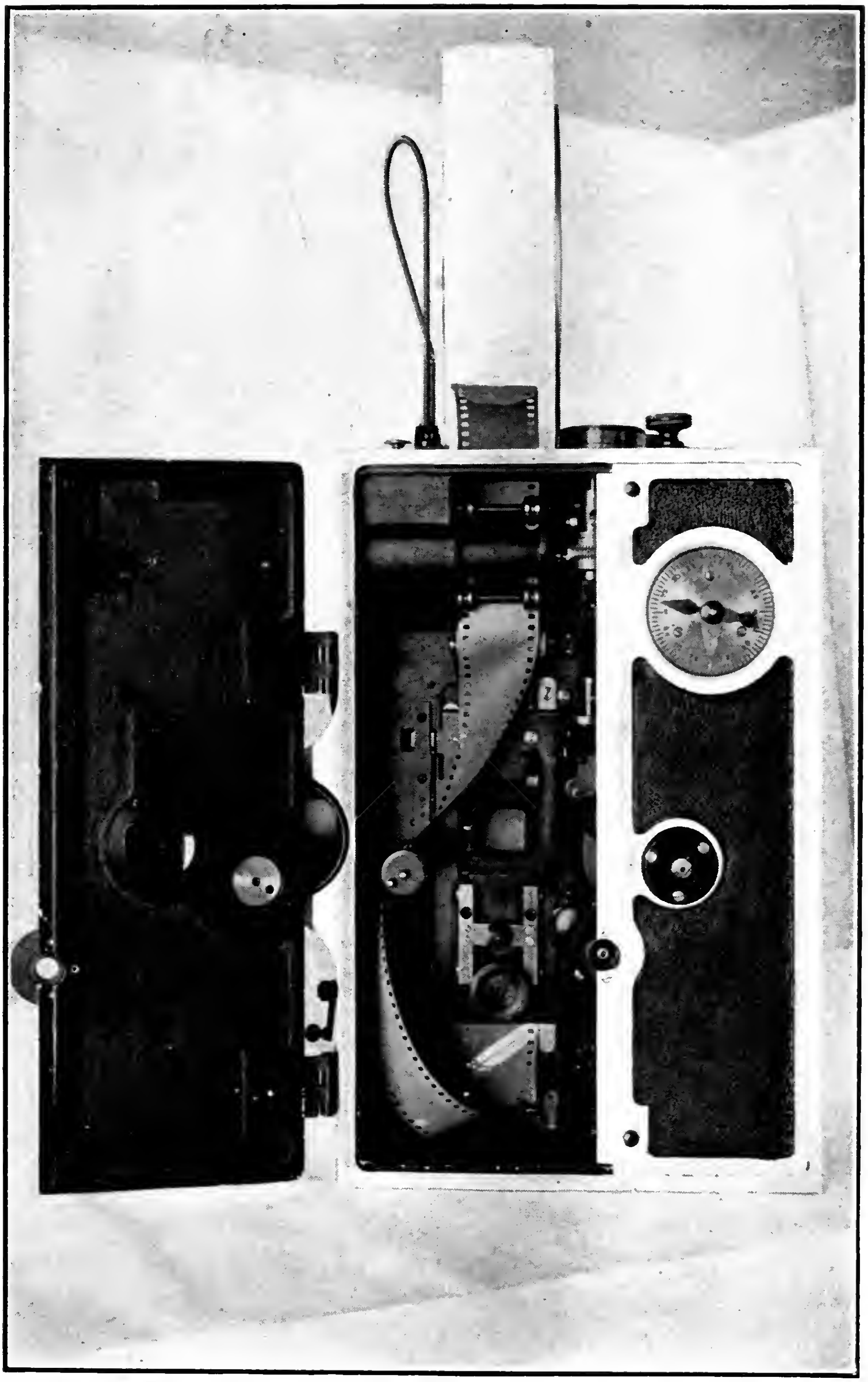
It is highly desirable that the pictures be accurately spaced at the standardized distance of three-quarters of an inch apart or sixteen pictures per foot. Each successive picture when thrown upon the screen will be as nearly as possible in perfect register, that is in exactly the same place upon the screen. If this is not done an unpleasant jumpiness or wavering of the picture will result.

In recording, that is in photographing, a motion picture at the rate of sixteen per second, there are several operations in making each frame or picture which must be accomplished in one-sixteenth part of a second. It is not possible to utilize all of this sixteenth part of a second in making the exposure because the film must be drawn down into position for a succeeding exposure before the next sixteenth part of a second. During this very short period of time it is necessary to cut off the light from the lens by means of the shutter, draw the film down accurately just three-fourths of an inch, hold it in place, and expose it to the image from the lens long enough to impress that image upon the sensitive surface, then completely cover the film exposed in the frame aperture before repeating this cycle of operations. All must take place in the sixteenth part of a second.

It will be appreciated that a mechanism which fulfills these conditions must be accurately and substantially constructed and be able to perform this cycle of operations many thousands of times without appreciable wear. It is possible to construct an intermittent mechanism which will draw the film down so rapidly that only a fifth or sixth part of this sixteenth of a second is used in changing the film, but such a mechanism wears out many times more rapidly than one which takes a longer time to pull the film down for the next exposure.

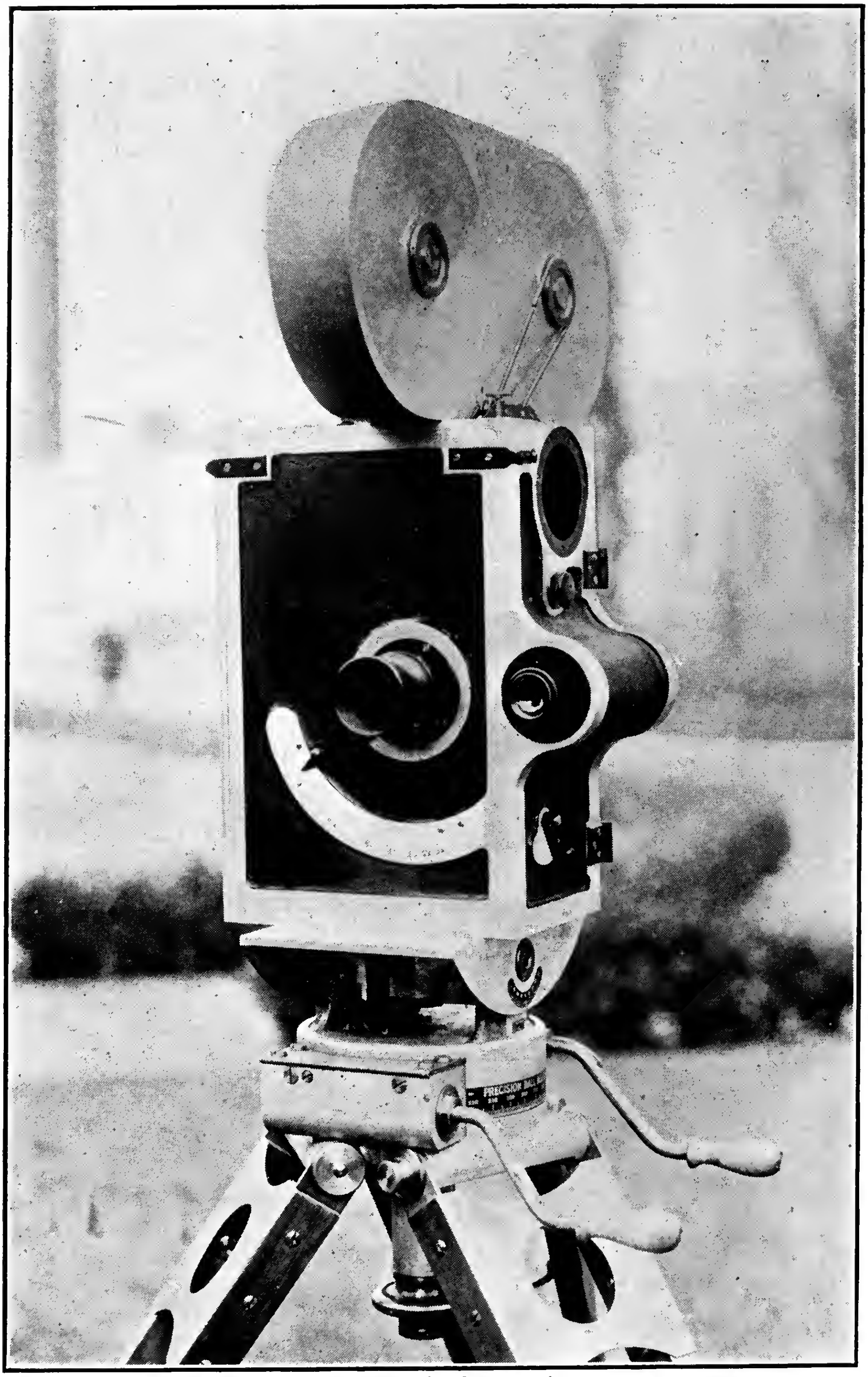
In constructing a camera, therefore, it has been the generally accepted practice to use an intermittent mechanism, comparatively slow in moving the film and to make up for its slowness by increasing the "rapidity" or "speed" of the film. Although these words are not correct, they are often used to indicate the sensitiveness of the photographic emulsion. Sensitiveness of the film is its ability to record the lens image in a given time.

There are many types of camera movement, but the best of these is probably the harmonic cam. This is often called the Lumiere, or the Lumiere-Carpentier movement, as it was first used in a camera of that name. The harmonic cam is a trian-



*(Courtesy Wilart Instrument Company)*

REAR VIEW OF THE WILART PROFESSIONAL MODEL CAMERA.



(*Photo by U. S. Signal Corps School of Photography*)

Wilart Professional Camera mounted on a Motion Picture Apparatus Company's Precision Ballbearing Tripod.

gular cam with curved sides, working between two guides which it moves up and down as it revolves. As it accomplishes the downward movement of the fingers in a third of a revolution it permits of a larger shutter opening than any other movement in general use.

The Geneva, or Maltese Cross movement has been used in camera construction, and while it gives a quicker downward pull of the film than the harmonic cam, it has several disadvantages which preclude its use. In the Geneva movement the downward draw of the film is accomplished in about an eighth of a revolution, but, as this movement has four bearing surfaces which are liable to wear unevenly it has not found much favor as a camera movement. Should one side, for instance, wear a trifle more than the other three sides, every fourth picture in the negative would be slightly out of register with the other three. In addition to this, slight variations in the thickness of the negative film, or its pliability, cause it to ride the intermittent sprocket more or less snugly, causing a variation in the frame line, or an up and down movement of the picture.

The harmonic cam, on the other hand, revolves once for each frame taken. Any small amount of wear, being the same for each successive picture, is not appreciable. This wear may be readily taken up in most constructions by loosening two screws which hold one of the guides between which the cam runs, and the guides may be adjusted firmly against the cam. The shutter opening with the Lumiere movement may be greater than 180 degrees, which is much more than any other movement in common use. The shutter blade could be reduced to 120 degrees were it not for the fact that it must have an additional width sufficient to cover the aperture opening, so that the smallest shutter blade that can be used in any movement is that fraction of a revolution during which the film moves downward plus a segment wide enough to completely cover the aperture opening from corner to corner. The Pathé, Prevost, the Universal, the Gillon, and many other makes of cameras, use the harmonic cam.

Almost all other movements are some variation of the rod and crank principle. That is, a rod, or other connection, fitted to a crank pin on the shutter shaft actuates the up and down movement of the claws. Since the downward movement of the crank is one-half of a revolution, no rod and crank motion can have as wide a shutter opening as the harmonic cam. Some of them decrease the time in which the film is moved down by having a crank whose throw is greater than the distance from picture to picture, and use only a portion of the crank throw for drawing the film down, the engagement of the pins or claws with the film taking place after the crank has commenced to move downward and releasing before the crank reaches the bottom of its throw.

There are many variations of the rod and crank movement. In the Pittman model the fingers are upon springs actuated by a crank. The fingers move in a circular path except when drawing down the film, where they are forced to subtend a chord of the circle by a friction plate in the plane through which the film moves. This friction plate being struck 16 times per second by the revolving spring claws makes this movement a very noisy one. In the Williamson movement a small arc-shaped slot guides the pins in an approximately straight line during the period of their engagement with the film. In other movements a double crank is used, giving both the in and out and up and down movement to the claws. A third variety of movement which was much used a few years ago was called the slip claw movement. In this movement the claws were ratchet-shaped and in their upward travel slipped along the perforation as a pawl slips over a ratchet.

The Pathé Frères formerly made an amateur model which used the slip claw movement. The slip claw movement has almost entirely gone out of use because it could not be reversed. No matter in which direction the crank of the camera was turned the slip claws would pull the film down in the same direction. An inadvertent throwing back of the crank, for even a fraction of a revolution, would cause the film to lose its upper loop. Unless there was a great nicety of adjustment between the friction at the gate and the pressure of the spring claws they were liable to push the film backward on their upward travel, causing the frames to overlap, thereby making what is called a creep in the film.

The in and out movement, or the movement of the pins in and out of the perforations, is accomplished in various cameras by many different methods. A positive in and out movement is much to be preferred over one which is accomplished by some sort of spring pressure. A positive in and out movement is one in which the pins are pressed in and withdrawn by a mechanical movement, such as a cam or drunken screw. In the Pathé or Gillon types the in and out movement is accomplished by a drunken screw. A drunken screw is a thread having an irregular pitch, the thread used for the in and out movement being a continuous one with the contours so placed as to force the pins into the perforations at the beginning of the downward throw of the cam and withdraw them at the bottom of the throw. In the Prevost movement the in and out throw of the pins is accomplished by small harmonic cams of the same design as the larger cam which produces the up and down movement. Most of the rod and crank types of movement have a cam working against a spring to push the fingers in and out, the cam pressing the fingers in and the spring pushing them out when released by the cam. It is possible to operate a movement of this type so fast that the spring does not have an opportunity to withdraw the fingers quickly enough, thereby causing creeping and losing of the loop. The Ernemann camera has a rod and crank movement with cam and spring for the in and out finger movement.

There are many types of movement beside those mentioned, none of which, however, are enough in general use to justify discussion here. In purchasing a camera, therefore, make sure that the movement is some modification of the harmonic cam with a positive in and out movement of the claws. A second choice is one of the better types of rod and crank movement. The DeBrie camera is one of the highest type of rod and crank movement.

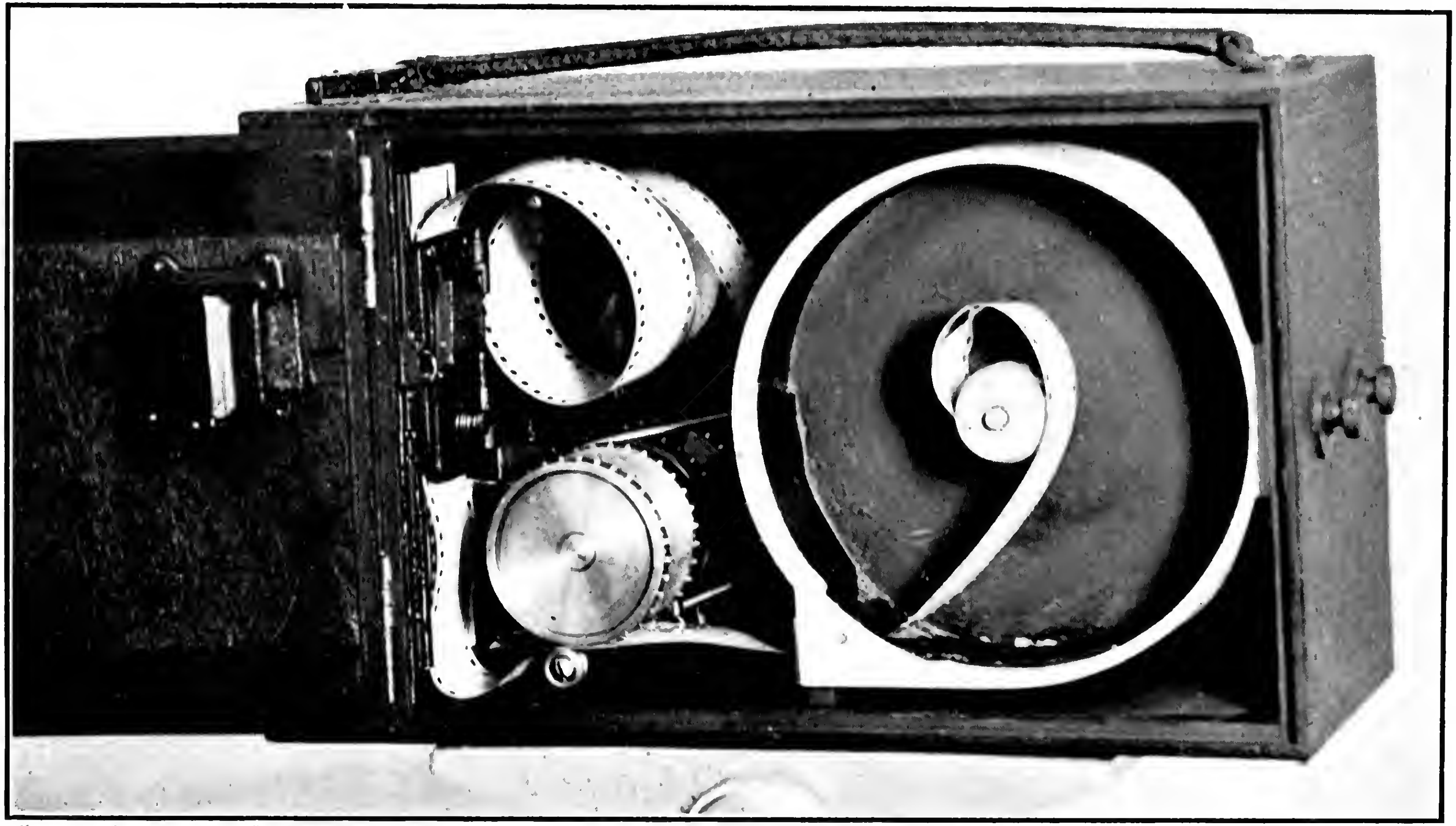
As nearly all parts of a camera movement shift backward and forward 16 times per second they are subjected to a great deal of wear. All of these parts subject to wear must, of course, be kept constantly but lightly lubricated, and should be provided with means for adjustment so that there is the least possible amount of play between bearing surfaces. The finger shuttle, that is a frame bearing the fingers, which moves up and down, is carried in some sort of guides which should be provided with adjustable gibs for taking up wear.

The shutter is the revolving blade which cuts off the light from the lens while the film is being moved downward for the next picture, or exposure. The circular revolving shutter is so universally used in motion picture cameras that it is almost unnecessary to take any other type into consideration. The shutter should consist of two blades, one of which is set immovably with a minimum area for keeping the aperture closed during the downward movement of the film. Another blade should be provided which may be adjusted so as to decrease the opening in the shutter by revolving it past the fixed blade, so that the opening may be entirely closed if necessary. While it is preferable to use the maximum opening of the shutter in most instances, there are many times when it is desirable, for various reasons, to cut down the exposure by means of the shutter opening instead of a smaller diaphragm opening.

A means for decreasing the shutter opening while the camera is in operation is called a shutter dissolve. By its employment are obtained such effects as fade-outs, fade-ins, dissolves, etc. There are two types of shutter dissolve, the automatic and the hand operated. In the automatic dissolve the pressure of a button on the camera throws a clutch into operation that closes the movable shutter blade gradually in a predetermined number of feet of film. With the hand operated dissolve the shutter may be closed gradually by hand in any length of film desired. Generally neither one of these features is provided by camera manufacturers, one of the few exceptions being the Bell & Howell camera, which has an automatic dissolve incorporated in the camera mechanism. So desirable is this form of dissolve that most professional cameramen have had them installed in their cameras by some mechanic who makes a specialty of cinematographic machinery. It is to be expected that most manufacturers will meet the demand for this device in their later models of cameras.

One of the hardest problems for the student motion picture photographer is the choice of a camera. The popularity of motion pictures has caused many inventors and promoters to place miniature or toy motion picture outfits on the market. While such cameras and projectors may have a field of their own among amateurs who have no serious intention of becoming professional motion picture photographers, they are of little use for any other purpose.

The reason for their existence is the decreased cost in their operation, by reason of the very small film which they use. This



*(Courtesy Bass Camera Company)*

THE U. S. COMPACT CINE CAMERA, A SMALL AMATEUR CAMERA OF 200 FEET CAPACITY, QUITE GOOD ENOUGH FOR SERIOUS WORK WHERE THE EXACTING REQUIREMENTS OF PROFESSIONAL WORK DO NOT HAVE TO BE MET.

puts them within the reach of those who could not otherwise afford the expense of private production. In some cases, they may be a boon to a student with professional aspirations whose financial position will not permit the purchase of apparatus using standard film. In general, however, the use of toy or miniature picture apparatus by those for whom the contents of this book are intended, is strongly deprecated. In the first place, cheap cameras using standard film may be purchased for the same price as a good miniature camera. In the second place, there is always a chance that the owner or user of a standard camera may be able to dispose of his production in some commercial way. On the other hand, there is no chance for the operator of the miniature camera to obtain any financial return of the expenditure which he has made.

By judicious forethought, the owner of a standard camera may conduct his experiments with very short lengths of film, using only a foot or two at a time. The cost of material need not influence even those whose financial restrictions are most stringent.

It must be understood that the purchase of a cheap camera for serious work is not recommended. By all means, purchase the highest grade of camera that your means will allow. Generally speaking, the price of a camera is in fairly direct proportion to the quality of work which it will produce. A cheap camera produces poor work because the manufacturer cannot afford to put accurate workmanship into it. On the other hand, some of the better makes of the cheaper cameras will produce pictures for certain purposes, which are almost, if not quite, as satisfactory as those made by a much higher priced instrument. It would be ridiculous for a man who expected to use his camera only for taking a few topical events for exhibition in a local theatre to buy an expensive studio outfit with an equipment of lenses, diaphragms, hoods and dissolves, when a cheaper camera would do perfectly well for his purpose.

So many different types and brands of cameras have been placed on the market that it is not possible to give a description of all of them here, but most of the principal types are shown in the illustrations and the reader must depend upon his judgment in selecting the type of instrument best adapted to his requirements.

The ease or difficulty with which the film may be threaded through the camera has an important bearing upon its usefulness. As a rule, a camera of a straight line threading, that is one in which there are no twists in the film in its passage through the camera, is the simplest and most desirable. On the other hand, the more compact models, in which the retorts are placed side by side, cannot be threaded without a twist in the film.

The general rule for threading the camera is as follows:

Place the feed retort in position.

Pull out as much film as is needed to thread the camera.

Pass the film over the feed sprocket and open the gate.

Place the film smoothly between the side guides with the emulsion towards the lens.

Close the gate carefully and latch, leaving a loop of film between the feed sprocket and the upper portion of the gate large enough so that pulling the film down in the gate for six perforations will not draw the loop taut between the sprocket and the top of the gate, and yet not so large that the loop will strike any portion of the camera mechanism.

Then leave another similar loop at the bottom of the gate.

Carry the film around the take-up sprocket beneath the rollers, through the light trap in the retort to the spool in the take-up sprocket and the take-up spool.

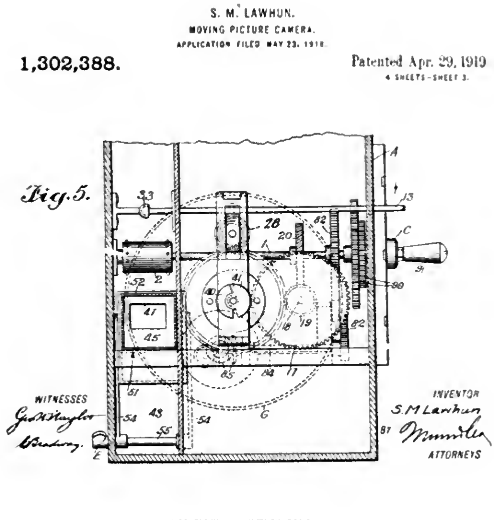
Fasten the cover of the take-up magazine.

Give the handle a turn to see that the film is feeding through properly and close the camera.

The film in the feed retort must be wound so that when the retort is in place the film is threaded properly, the emulsion side of the film in the gate toward the lens. In straight line threading the loop is not a true loop but only a slackness in the film to provide for a quick downward movement of that portion of the film within the gate when it is dragged down by the claws.

In cameras with the magazines side by side a true, or return, loop must be made in the film between the feed sprocket and the gate and between the gate and the take-up sprocket. Types of the double return loop threading are found in the DeBrie, Pathé Portable and Newman & Sinclair cameras.

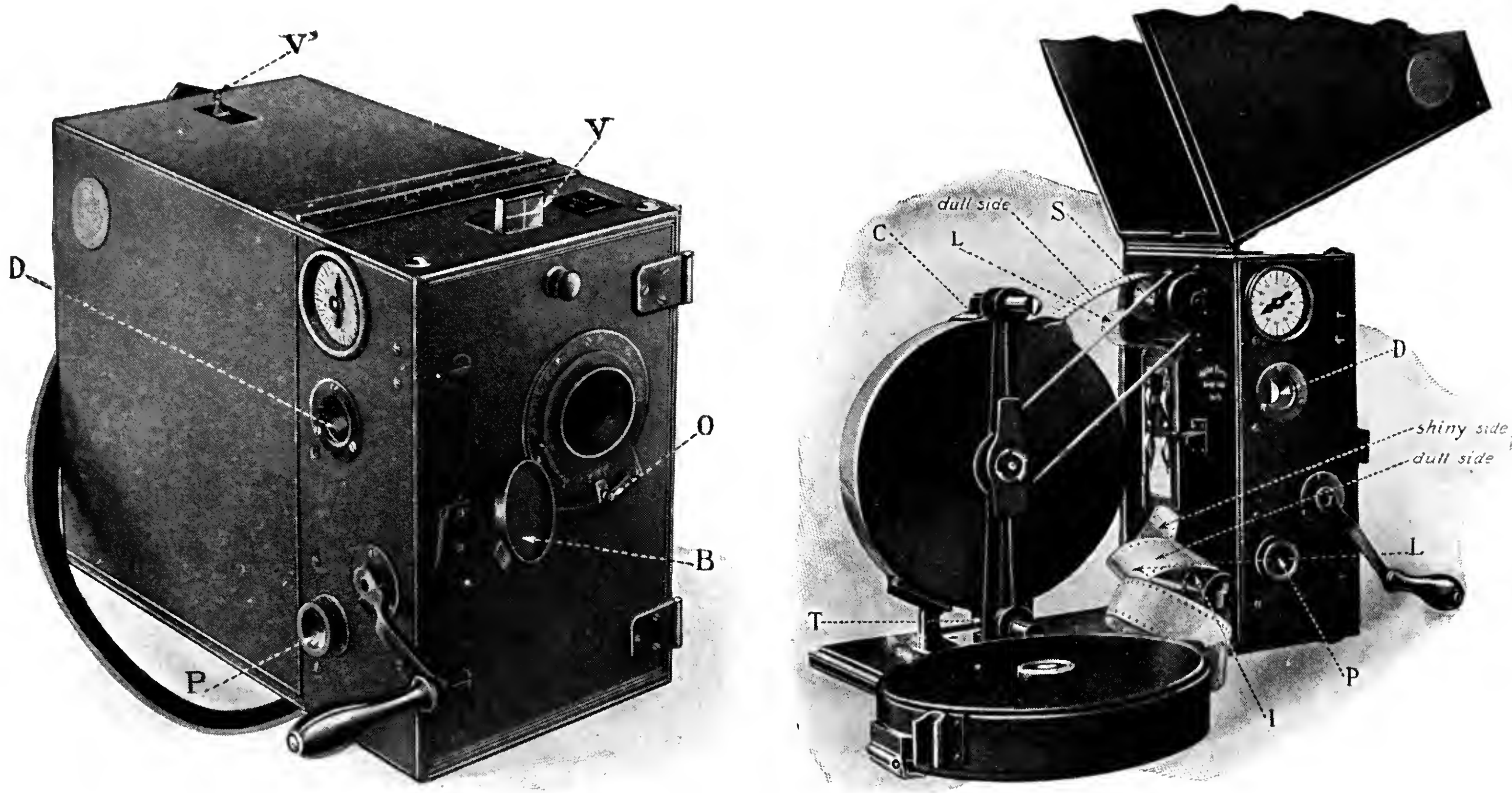
The Prevost, carrying its magazines side by side on top of the camera, is an exception, the feed magazine being directly above the feed sprocket and gate, feeds downward in a straight line





THE "LAWHUN" MOTION PICTURE CAMERA. INVENTION OF S. McKEE LAWHUN, PRESIDENT OF NEW YORK INSTITUTE OF PHOTOGRAPHY

(An improvement over Mr. Lawhun's former patent. See diagram.)




WELL KNOWN PATHESCOPE CAMERA FOR AMATEURS and simple loop into the gate. From the bottom of the gate it goes upward and to the right in a long single loop, without a twist, to the take-up sprocket, where it feeds directly into the take-up retort. The return, or true, loop is the same sort of a loop as would be formed by wrapping a piece of film in a spiral direction about a round object, while the simple loop of straight threading is merely a slackness in the film without any other twist or turn.

In addition to the simple directions given here there are a number of variations in different cameras which provide rollers for guiding the film in various directions. For example, in the old style Gillon a roller is provided which brings the film in a straight line from the feed retort, from whence it passes over another roller before passing to the feed sprocket; the object of the second roller being to engage the film around a greater part of the circumference of the feed sprocket, in which only two teeth would engage the film around a greater arc of the sprocket's circumference.

## Chapter V

# CINEMATOGRAPH LENSES

TECHNICAL terms used in photography are often puzzling to the amateur, particularly those terms which relate to the science of optics. The following glossary of optical terms has been prepared to give general information as to the descriptive words and phrases in ordinary use.

*Equivalent focal length.* Focal plane, is the plane in which a far distant object is imaged by the lens. The line drawn perpendicularly through the center of the lens is its *Optical Axis;* the point at which the *Focal Plane* intersects the *Optical Axis,* the *Focal Point* of the lens.

The *Focal Length* of a lens is the value upon which depends the size of the images produced by that lens. Its magnitude can be determined only by comparing the size of a given object with its image as formed by the lens. The distance of the object, unless very great, must also be considered.

For far distant objects the size of the image is in direct proportion to the focal length. A lens of 12-inch focal length will produce an image of a distant steeple twice as large as the image formed by a lens of 6-inch focal length.

*Back Focus* is the distance from the focal point to the rear surface of the lens. In very thin lenses, this back focus is equal to the focal length. In lenses of considerable thickness and in combinations of lenses, the back focus cannot be relied upon as any indication of the value of the focal length. The focal length of such a lens is equal to the focal length of a thin lens, which gives an image equivalent in size to the one formed by the combination lens, hence the term *Equivalent Focal Length.*

In using short focus cinematographic lenses it is important to know both the back and the equivalent foci, since the construction of some makes of motion picture cameras is such that the revolving shutter has not been placed close enough to the aperture to admit a lens of very short back focus without interfering with the shutter blades.

*(Photo by U. S. Signal Corps School of Photography)*

Lt. Charles Downs, S. C. U. S. A., operating a Bell and Howell Camera. The Bell and Howell Camera is all metal and has a turret which holds four lenses of different focal lengths.

The installation of a 35 mm. lens often demands considerable alteration in a cine camera, not only of the shutter, but of the front board as well, since the lens flange ordinarily used with lenses of longer focal length is apt to cut off the corners of the picture.

On account of the exaggerated perspective, lenses of extremely short focus are not recommended for use except where limited space prevents the use of a lens of sufficient focal length to give a normal perspective.

In the majority of photographic lenses the equivalent focal length is greater than the back focus, an exception being found in single meniscus or single concavo-convex combinations, which are practically never used as cine lenses where the back focus is the longer.

By measuring back from the focal point a distance equal to the equivalent focal length, we find the position of the so-called optical center of the lens, which is nearly always near the diaphragm.

*Angle of view* is the angle under which the diameter of the circular area covered sharply by the lens appears from the center of the lens. If the largest plate, which the lens covers sharply, is used, the angle of view is equal to the angle under which the diagonal of the plate appears from the center of the lens. The angle of view increases with the increase of the focus of the lens or the same size plate. Lenses for general purposes are calculated for an angle of about 60°. Lenses covering 75° to 100° are termed Wide Angle Lenses. Wide angle lenses have necessarily shorter foci than other lenses rated for the same plate.

As a motion picture is customarily viewed at a distance relatively greater than a still photo the angle of view averaging nearest normal is about 28°, using the base and not the diagonal of the picture as a basis for calculation. This is the angle subtended by a two-inch lens on the standard ¾ by 1 inch aperture or picture frame. Lenses of shorter focus than this are termed wide angle, although the angle of view is still not so great as that found in many still pictures which are taken with lenses which would be far from being considered wide angle for an ordinary photograph.

The circular area which is covered by the lens on the ground glass is called its *image circle,* and its diameter is expressed in linear measure (inches or centimeters).

*Effective aperture* is measured by the diameter of the beam of light admitted by the lens. The effective aperture is not, as often thought, equal to the diameter of the front lens, nor is it equal to the linear diameter of the diaphragm opening used. It equals the diameter of the diaphragm as it appears when observed through the front lens; therefore, the effective aperture cannot be found by unscrewing the front lens and measuring the actual diameter of the diaphragm. Only in the case of a landscape lens, or meniscus, where the diaphragm is placed in front of the lens, is the effective aperture expressed by the linear diameter of the diaphragm.

The actual diameter of the effective aperture may be obtained by placing a piece of developing paper against the glass of the front combination of the lens and exposing it through the lens. The diameter of the round black spot obtained by developing the paper is that of the effective aperture of the lens.

The effective aperture varies, of course, with the size of the diaphragm opening.

*Relative aperture* is a fraction which expresses the ratio of effective aperture to focal length; for instance, relative aperture of 1:6.3 means that the focal length is 6.3 times greater than the effective aperture. The denominator of the fraction, in this instance the figure 6.3, is called the F value. If the relative aperture is known, the effective aperture can be found by multiplying the relative by the focus. For example: F:160; relative aperture = 1:8; effective aperture = 160 x 1:8 = 20. The relative aperture is a term of greatest value and convenience in judging the time of exposure. All lenses of the same relative aperture, no matter what their focus may be, require the same exposure under the same conditions. An exception will be mentioned under the heading "Depth of Focus."

The exposure necessary for different relative apertures can be found easily because they are proportionate to the square of the F values. For instance, if two lenses are compared with the relative apertures 1:4 and 1:8 respectively, the squares of F values are 16 and 64 respectively, which means that the 1:8 requires four times as long exposure as the 1:4 lens, since 64/16 = 4. This, of course, holds true also in comparing the different stops.

*Speed.* The relative aperture is very commonly called the speed of the lens, although speeds of two lenses are not proportionate to their relative apertures, but to the squares of the aperatures. In other words, a lens with the speed of 1:4 is not twice as fast as a lens with the speed of 1:8, but four times so, as the comparison of the squares of their relative apertures 1/16 and 1/64 shows.

There are two methods of designating lens stops, *viz*: the so-called F System of the Royal Photographic Society, wherein the stop is expressed by fractions of the focal length, and the U. S. (Uniform System), in which every following stop requires a doubling of the exposure or represents half the speed of the foregoing, the exposure required with F:4 being taken as the unit.

Comparison between the F system and the U. S. (Uniform System) of Stops:

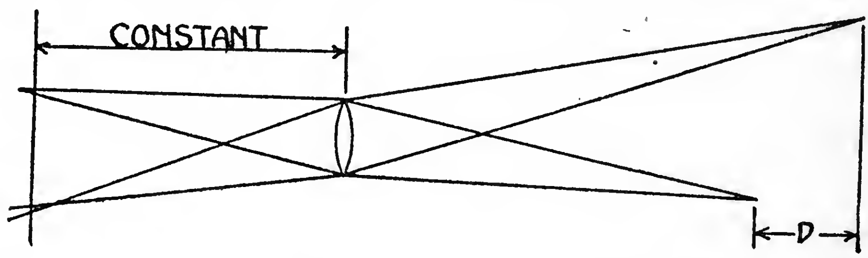
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| F. System...... | F:4 | F:4.5 | F:5.6 | F:6.3 | F:8 | F:11.3 | F:16 | F:22.6 | F:32 |
| U. S. System... | 1 | 1.2 | 2 | .2.5 | 4 | 8 | 16 | 32 | 64 |

The above table gives the comparative stops in the two systems and shows at the same time the exposure values of the different stops in the F system. For instance, F:11.3 requires four times as long as F:5.6; and F:32, an exposure sixteen times longer than F:8, since $8/2 = 4$ and $64/4 = 16$.

At first glance it would seem that the U. S. system would be the more convenient one to use since it gives the relative exposure direct, but in practice it is really just as simple to use the F system if it is well fixed in the mind that each succceding F number as customarily marked on the lens barrel is half the speed of the preceding one. Wherever any calculation is involved the F number is the one used and a U. S. number must first be resolved to its F equivalent to obtain a result. The U. S. is becoming obsolete except on some of the simpler hand cameras with low grade lenses.

*Depth of focus.* Very closely connected with the speed of a lens is its depth of focus. All well-corrected lenses image only one plane of the object space sharply. The reason why a lens focused at a house images also with sufficient sharpness, a horse in front and a tree back of it, is that a slight racking out of focus will not cause an indistinctness great enough to be noticeable to the eye. The range of sharpness forward and back of the object is called "depth of focus" or "depth of field." It depends on several factors, *viz*: the focal length of the lens, the aperture used (consequently its speed), the distance of the object, and the amount or lack of sharpness which seems permissible to the operator. Of these factors, focal length, aperture and distance are definite numerical values.

That the amount of indistinctness permissible on the picture is susceptible of numerical expression is easily seen from the following: If an object at a given distance is in sharp focus, the




D is the Depth of Field and is that distance between two planes within which all objects are rendered reasonably sharp on the ground glass. It varies directly as the *f*: value and inversely as the focal length.

light issuing from a point of that object is converged to a point on the plate. Light issuing from a point in the original object will also be converged to a point, but not on the plate, the cone of light showing in either case a circular patch of light on the plate. This circle of light is known as the "circle of confusion." Its diameter can be used to express the amount of indistinctness existing in a picture. If the circle of confusion is not greater than 1/10 mm. or 1/250 inch, it would appear as a point to an eye 10 inches away, hence, an object no point of which is imaged by a circle larger than 1/10 mm. would appear sharp.

No matter what their type of construction may be, all lenses of the same equivalent foci and the same relative aperture require the same exposure—that is, have the same speed, other conditions being equal. They will have the same depth also.

The depth of focus decreases: 1. with increase of focal length; 2. with increase of relative aperture (speed); 3. with increasing nearness of object.

Of two lenses of equivalent foci, the one with the lower relative aperture (speed) has the greater depth of field. On the

(*Courtesy Robertson-Cole Studios*)

TAKING EXTERIOR SCENES WITH WILLIAM DESMOND IN "THE MINTS OF HELL" AT TRUCKEE, CAL.

other hand, if the focal length of the lens is very short, a speed as high as F: 4.5 will allow bringing every object from 10 feet to infinity to a sharp focus, while a studio lens of long focus and the same speed may not even image an object of the depth of a head sharply within the range of the length of a studio.

Speed, great focal length and depth of focus cannot be combined in the same lens. This is an unalterable law of optics. If speed be the most desirable quality, depth of focus must be sacrificed; if depth of focus, speed. This does not detract from the value of fast lenses, because with a given lens the depth of focus can be increased by diaphragming down the lens which means reduction of speed. If a short exposure demands the use of the lens wide open, one must not expect great depth of focus. Under ordinary conditions of light and distance, with fair judgment, and with lenses not too long in focus, these opposing qualities may be happily combined, so that lack of depth is hardly perceptible.

Some apparent exceptions may be stated, for instance, a lens which produces images of general "softness," *i.e.,* a lens in which the aberrations are not corrected to the utmost perfection. Such lenses, which lack snap and brilliancy, may show greater depth of focus than a first-class lens. There is less difference between the "sharpest" focus and the image of objects forward and back of it, simply because the "sharpest" focus itself is not really sharp. Thus the statement that one lens has a greater depth of focus than others of the same aperture and focus, must be regarded as rather detrimental to the lens, for as stated above, depth of focus cannot be made subject to special correction.

Another case may be mentioned in which one lens may really have an advantage over another in regard to depth of focus. In some camera constructions correction of astigmatism is obtained at a great sacrifice of simplicity by employing an unusual number of lenses separated by air spaces. There is a certain loss of light by reflection on a lens surface and it is easily intelligible that the fewer reflecting surfaces in a lens, the smaller the loss of light. In some constructions the number of the lens surfaces runs as high as ten, while the Tessar contains only six. The consequence is that the lens with the greater number of reflecting surfaces requires a longer exposure than a lens of simple construction, although both may have the same relative aperture.

Or to express it differently: the lens with the greater number of reflections requires an aperture of F:6.3 with a certain time of exposure, while the other lens will give a negative of equal density with its aperture stopped down to F:7.2 or F:7.5, which means a gain in depth of focus for the lens with the smaller number of reflecting surfaces.

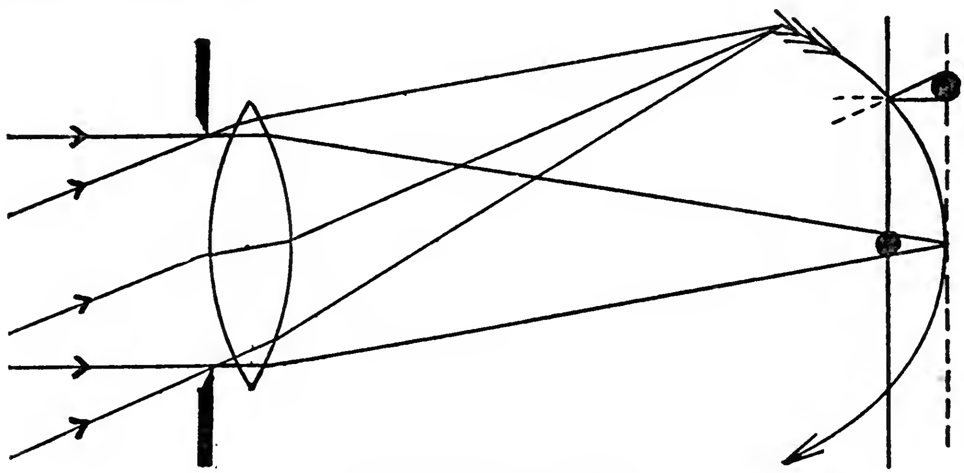
Cinematograph lenses are usually made with the smallest number of reflecting surfaces consistent with the requisite correction. They are also slightly faster than larger lenses of equal aperture because their small size makes the glass to be traversed by the light much thinner.

*Spherical Aberration.* Owing to the fact that lenses are made with spherical curves, all single collective lenses have the defect of imaging an object through their marginal zone at a shorter focus than through their central zone. Such a lens may give a sharp image with a small central diaphragm, and a sharp image as well if the center is covered with a round opaque stop so that only an annular zone around the margin comes into action. But both images will not lie in the same plane, nor will they be of the same size. Even if a lens is spherically corrected, so that the parallel rays penetrating the lens near the optical axis and those going through the lens near the margin come to exactly the same focus, there may be a slight remnant of spherical aberration in the zone between center and margin. Small remnants of this kind (so-called Zonal Errors) are found in almost all photographic lenses, especially of the cemented symmetrical type. The unsymmetrical combination upon which the Tessar construction is based, allows a better correction of the zonal errors than any other known construction. The greater the relative aperture (speed of the lens), the greater the task to correct the spherical aberration for all zones of the lens.

Unsatisfactory spherical correction is indicated either by a general indistinctness of the image or by a fairly sharp image, which is entirely covered by halo (fog). Stopping down the aperture may improve the performance of a badly corrected objective.

*Coma.* The spherical aberration of pencils of light going through the lens in oblique direction is called coma. This manifests itself in the fact that although objects in the center of the field appear perfectly defined, objects outside the center show a one-sided indistinctness which increases toward the margin of the field, and in the image of a point-shaped object assumes the form of a tail like a comet, wherefrom this aberration takes its name. Stopping down reduces the amount of coma.

*Astigmatism* is that aberration which withstood longest the efforts of the opticians. A lens which is not corrected for astigmatism will not image sharply horizontal and vertical lines at the same time near the margin of the plate, although the center of the image may be perfect. This aberration is inherent in narrow pencils of light, so that stopping down the lens will not decrease the amount of astigmatism to the same degree that it decreases other uncorrected aberrations.



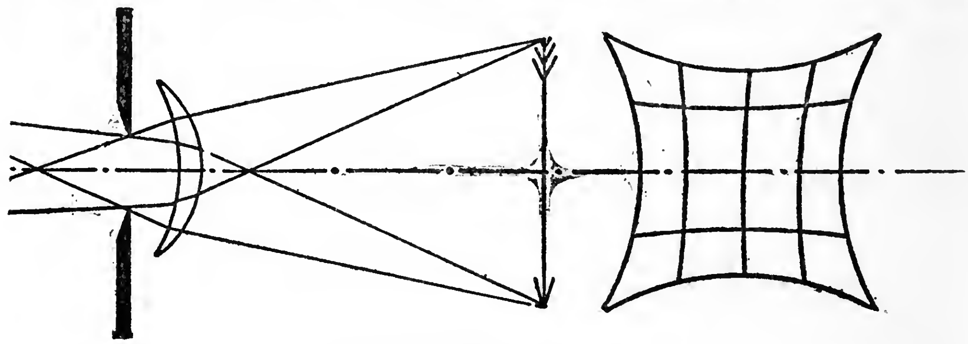
CURVATURE OF FIELD

In the absence of a test chart a very simple test for astigmatism may be made by focusing on the joints of a brick wall. No matter how much the lens may be racked in or out, both horizontal and vertical lines will never be sharply defined at the same time near the margin of the plate.

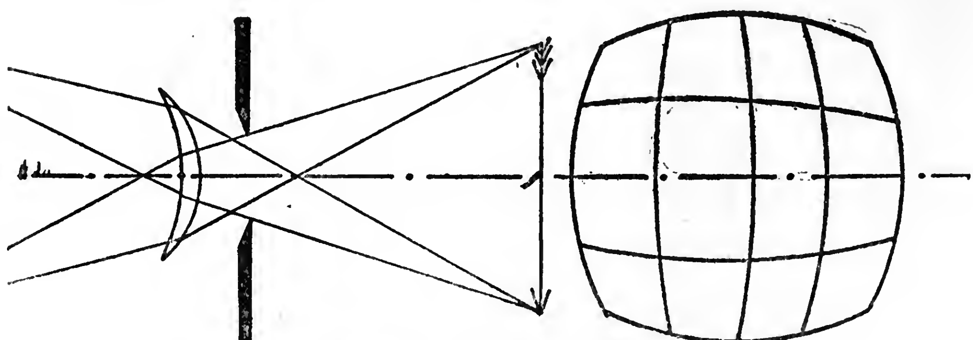
*Curvature of Field.* The ordinary lens images a flat object, not in a plane, but in a spheroidal surface, so that when the center of the image is focused sharp, the ground glass has to be brought nearer to the lens to obtain a sharp image of an object point near the margin of the plate.

It is only in recent years that it is possible to correct astigmatism, together with the curvature of field in lenses of high speed. Lenses which are free from spherical aberration for a large aperture and produce a flat image free from astigmatism, are called "Anastigmats," the prefix "an" meaning "without," hence, without astigmatism.

*Distortion* is that fault of a lens which prevents the rendering of straight lines as such. The straight lines are reproduced as curves. All single lenses used with a diaphragm in front (landscape lenses) are subject to this defect in some degree. The distortion is called "cushion-shaped," when the



PILLOW DISTORTION.



BARREL DISTORTION.

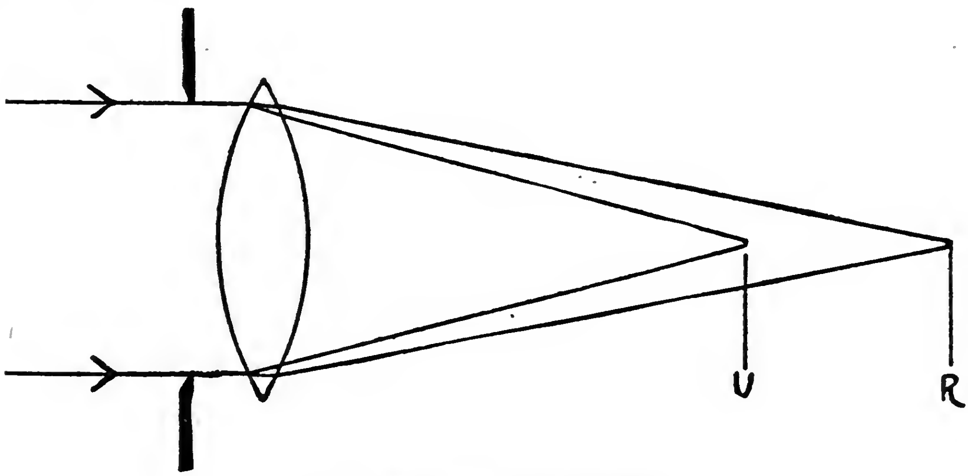
curves are concave, and "barrel shaped," when the curves are convex toward the margin of the plate.

Lenses which are free from distortion are called rectilinear.

A lens which distorts cannot be improved by using smaller stops.

Distortion has nothing to do with curvature of field. The image can be properly flat and the definition perfect, and yet straight lines may be distorted into curves.

*Chromatic aberration* is due to the fact that in a lens, unless corrected from chromatic aberration, the visual rays which form the image seen on the ground glass do not form the images at the same position as the actinic or chemical rays, which affect the sensitive plate. Since the image is focused with rays for which the eye is most sensitive, the image formed by the rays for which the plate is most sensitive will fall outside of the visual focus (focal point), and therefore must be blurred on the plate. Of course all photographic lenses which are of any value at all must, first of all, be corrected for chromatic aberration. An objective which has chromatic aberration is sometimes said to have chemical focus.




CHROMATIC ABERRATION
U—Focal plane of Violet Rays
R—Focal plane of Red Rays.

This is not an uncommon defect in cinematograph lenses, but may easily be tested for by focusing upon coarse printed matter with other placards at varying distances before and beyond the one focused upon. If any of the placards film clearer than the one focused upon it is plain proof that the visual and chemical foci do not coincide.

*Definition* is that quality which enables a lens to produce sharp and crisp images, and its presence in an objective is a proof of exact workmanship as well as careful computation. The best workmanship will be wasted in a lens not well designed, and bad workmanship will annihilate the best computer's skill. If the various defects and aberrations are corrected and the workman has done everything to carry out the designer's ideas, the lens will give at full aperture a flat and sharply cut image over the entire area covered. The area covered with perfection is sometimes called area of critical definition. Since most of the aberrations depend upon the opening of the lens, the definition may be improved in some cases by reducing the opening at the sacrifice of speed.

*Illumination.* We speak of even illumination when the margin of the plate receives as much light as the center, and the negative shows an even density over its entire surface. A perfectly even illumination is only possible with small stops, especially when a larger plate than the lens is rated for, is used. All speed lenses when used with full aperture, show more or less drop in the illumination (vignetting) toward the margin of the field covered.

This vignetting or cutting of oblique rays by the lens barrel is apt to show quite plainly in pictures taken at large aperture with extreme short focus cine lenses. To get a full exposure at the edges may even require a slightly larger diaphragm opening than is needed with a lens of longer focus where the vignetting effect is imperceptible within the small area of the aperture plate.

*Covering Power* is expressed by the area which the evenly illuminated flat field covers with perfect definition. It depends upon the diameter of the lenses and on the degree to which the different aberrations are corrected and may, in some cases, be increased by using smaller stops.

The greater the relative aperture and the greater the covering power, the more valuable the lens.

*Flare Spots.* Occasionally a negative will show a nebulous patch of light covering shadows and high lights alike. Such patches are called flare spots or ghosts. They are formed by light reflected within the lens, at the lens surfaces bounding air spaces. It may be stated as a rule that every lens having an air space will show a flare spot under some conditions. Although it is possible to so adjust the curvature and direction of the lens surfaces that the flare spot is spread over nearly the whole plate (therefore not noticeable) this generally could be accomplished only by sacrificing more important corrections.

Before it can be said that one lens is superior to another with respect to flare spot formation, the two lenses must be thoroughly tried out under a great variety of conditions of illumination. Generally it will be found that if a lens shows a flare spot and another of different construction does not, by changing conditions, the second lens will show a flare spot and the first will not.

Very small stops may show flare spots when larger stops do not.

Flare spots are most apt to appear when photographing an object against a strong light and least apt to appear when the light is coming from back of the camera.

A condition resembling flare is apt to occur in a dirty lens particularly from almost imperceptible spots from oil spattered by the camera mechanism or from finger prints. Moral: Examine the lens frequently and keep it immaculately clean and well protected.

Flare will occur with the best of lenses if strong extraneous light is allowed to strike the lens. Moral number two: Use a lens hood.

## Chapter VI

# FOCUSING THE CAMERA

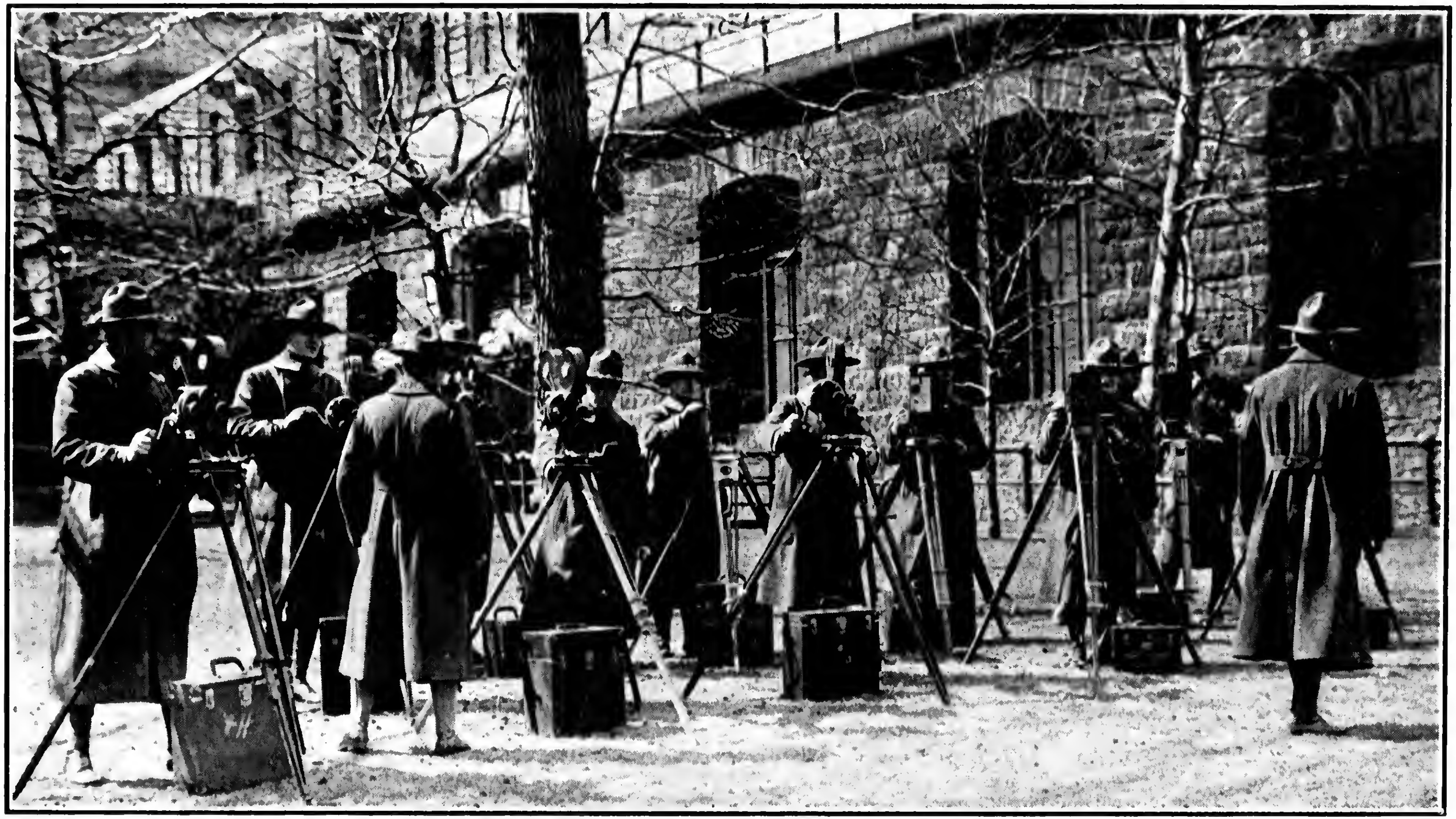
THE first requisite for obtaining a sharply defined image on cine film is focusing the lens accurately. The poorest lens made will make a sharper image at its focus than the best lens made which is out of focus.

Most cinematographers are prone to focus each scene upon the ground glass or upon the film for every different set up of the camera and many even focus between scenes in the same set taken at the same distance. This is decidedly wrong and a grievous waste of valuable time. Often the cameraman has used from five to fifteen minutes of the entire producing company's valuable time in obtaining an accurate focus.

This is not a criticism of the photographer who composes his picture on the film aperture, although many also take an unnecessarily long time for that operation.

The fact of the matter is that no man can focus as accurately every time as a well mounted lens can be calibrated for focus and the cameraman who has not taken the time to accurately scale his lens must be very inefficient in focusing. Many of them do not seem to know that the focal distance of the lens is always the same for any object at a given distance from the camera. Others are content to work with a camera so ramshackle that even if they were to calibrate their lens mount it would not work the same two days in succession. A tape line measurement from the front of the camera takes but a moment and with the lens properly scaled on a solid mount the photographer is always sure of a sharp focus.

The scale is almost indispensable to the topical operator whose work must often be made on the jump. He can soon learn to estimate with his eyes within a few inches or feet of the distance of the principal figure that he is taking. A few feet away from the camera the depth of focus is so great that it is easy to set the lens quickly between fifteen or twenty feet and the infinity mark and be absoluely sure of a sharp focus. He must have



*(Photo by U. S. Signal Corps School of Photography)*

CLASS IN MOTION PICTURE CAMERA OPERATION USING FIVE BELL AND HOWELL, ONE PATHÉ PORTABLE, ONE UNIVERSAL, ONE PATHÉ PROFESSIONAL, AND TWO DE BRIE CAMERAS.

very poor judgment indeed if he cannot estimate distances under fifteen feet within a very few inches. The more careful studio worker can always verify his judgment with the tape measure and in many cases, by a proper arrangement of his focusing device, is able to change the focus as a figure advances toward or retreats from the camera.

In this day of multitudinous effects of moving cameras on trucks and wheels, slide ways and moving cranes, it is essential that the up-to-date worker be able to change the focus while taking pictures.

We shall soon have practical motor-driven cameras and gimbal panoramas which may be turned in any direction without the use of two panorama handles at once, as is now necessary to produce a straight diagonal panorama. These are logical conclusions and even today many of the effects must be produced by two and even three or more working simultaneously with one camera. Simplification of manipulation should be sought by the operator who wishes to keep in the front rank.

Here are a few simple directions for scaling or calibrating a lens mount.

Before starting to scale the mount give your camera a thorough looking over, making sure of the following points:

First—That the film in its travel past the aperture plate or frame opening is always in flat contact with the opening; that there is no possibility of the pressure plate sliding askew in its seat on the gate and producing an uneven pressure against the film; that the side guides are not so close together that they will, by pressure against the edges of the film, cause it to belly or buckle; that the fingers, claws, or pins, that feed the film down for each frame are in perfect alignment and do not wrinkle the film by a diagonal downward pull, caused by the pin engaging and dragging the film down by a pull on one side only; that the gate tension is always sufficient to hold the film against the frame place securely but without needless friction.

It is well to mention here also that velvet lined tracks, pressure plates and gates are not only an abomination when trying to obtain accurate results in focusing, but are also great scratch and static breeders and should be replaced wherever possible with some hard, non-corrosive metal polished to a glass smoothness, as perfectly straight and flat as can be obtained, and with short tapers and rounded edges at all points where they receive the moving film.

Second—That the parts of the camera which hold the flange of the lens mount should be so rigid as to eliminate any possibility of there being the minutest change in the distance between the frame aperture and the lens mount. Wood is far too liable to warp and bulge to be trusted for a lens front board and any wooden front board supporting the lens, should be changed to one of metal or other rigid material and firmly connected to the metal frame of the camera by metal struts or columns to which it may be firmly screwed or clamped. Bayonet joints are used for this purpose in many cameras. If they are used they should be frequently inspected to see that they have not worn and permitted play between the locking keys and the lens frame.

Third—The backlash or play or lost motion in the focusing mount itself should be reduced to a minimum. In many cameras, especially those in which the focusing is done from the back by a system of rods and connections, it is impossible to eliminate a considerable amount of this lost motion. If it can be assured that this backlash is a constant factor, that is always the same, it may be advisable to calibrate in both directions.

For example, suppose the camera was focused upon an object fifteen feet away and one wished to change the focus to ten feet. If the backlash were considerable the pointer might be moved back to the scale mark for ten feet without moving the lens, in which case the camera would still be focused at fifteen feet and to make the lens move to the right focus for ten feet, the points would have to be pushed on to the mark for eight feet, although the backlash now being in the opposite direction would allow it to be brought back to the ten mark without moving the lens. As this backlash is generally a constant factor, the error produced by it is avoided by making two scales, one for the pointer when being turned in one direction and another for it when turned in the opposite direction. Such a focusing device is, of course, more sensitive to wear than any other and should be carefully checked for error at least once a month.

Having thus checked up the sources of error in the camera, we are now ready to scale the lens mount. For this we need a piece of very fine ground glass the same width as the film, a good focusing or small magnifying glass, a tape line, and a test chart. Lens testing charts may be obtained from any good optician: Bausch & Lomb or Wollensack Optical Company, both of Rochester, N. Y., each publish good ones which they would probably be glad to send for ten cents postage. For our purpose, however, a newspaper with some bold headlines will serve perfectly well.

Set the camera up rigidly on the tripod and pin the newspaper or test chart against a well lighted wall. If you can improvise some sort of light easel for the chart it will be much easier to move it accurately to the different distances, than to move the camera. Place a short strip of film in the gate of the camera, remove the front board and, with calipers, compasses, or a finely divided scale, make sure that the distance from the film to a steel straight edge held across the camera front is exactly the same as the distance from the straight edge to the ground surface of the ground glass when it is held at the aperture instead of the film. If there is any variation in this distance the film is either buckled or out of contact and the cause should be found and remedied. After checking the film in this way a second time, we may now feel reasonably safe in going ahead with our calibration.

First rack the lens out as far as it will go and with the ground glass in place and making sure of minute sharpness move the chart or the camera until the chart is in focus. Now with the tape line, measure the distance from the front board to the chart. This distance will be the closest that you can bring an object to your camera and have it remain in focus. This distance depends on the range of the focusing mount and is ordinarily one to three feet. If you wish to make closeups of small visiting cards or other small objects you can do so by using a supplementary lens like the kodak portrait lens or have a mechanic make you an extension ring one side of which fits the lens flange and the other side the lens mount. By the use of this you can extend the distance between the lens and the film and thereby regulate the magnification.

With a sharp steel point mark this as the first point on your scale and the distance which it represents; then at successive greater distances, each carefully measured and recorded on your scale, complete your range of distances, 18 inches, 2 feet, 3, 4, 5, 6, 8, 10, 12, 15, 20, 35 and infinity being a good range. Distances between these can be estimated easily as being proportionately between the nearest known distances on the scale. For objects closer than three feet, unless your scale is marked in differences of a few inches, it is safer to use the ground glass; as the nearer the object the greater the change in the focal distance of the lens.

If you have followed these directions closely you can with the aid of your tape measure be sure of getting your pictures in focus every shot.

Besides the purely mechanical errors that are liable to occur in focusing a cinematographic lens, there remain others to which reference has not been made.

These come chiefly under two heads: First, the inherent errors of the lens; and second, errors in the method of focusing.

Cinematograph lenses are not apochomatic, that is, corrected for light of all different wave lengths. If, however, they have been corrected for visual and actinic focus this is of no particular importance as the ordinary brands of film are only sensitive to the actinic blue and blue-violet rays.

Without entering too deeply into the physics of light rays and their wave lengths, it is still important that we take into consideration some of their better known properties and discuss them with relation to the subject in hand.

We are all familiar with the brilliant band of prismatic colors which results from passing a ray of white light through a prism. The light waves may be compared to sound waves of different pitch and there are many light waves which are invisible to the human eye just as there are sound waves too low and too high in pitch to be audible to the human ear. The red end of the spectrum is the low pitch end, or long wave length end, and does not affect ordinary photographic emulsions except by greatly prolonged exposure. For this reason we illuminate dark rooms with red lights, to which our eyes are sensitive while the film is not.

The actinic and visual rays are not two separate and distinct kinds of light, but are terms which are used to designate two different sections of the spectrum which overlap one another.

(*Photo by U. S. Signal Corps School of Photography*)

Students receiving instruction in the use of the Akeley camera. This ingenious instrument can be panned and tilted in any direction by the handle projecting at the back. It has a focal plane shutter and numerous other improvements found in no other make of cine camera.

The visual rays are those which we discern when we make the spectrum with a prism as has been described—the actinic, however, begin in the region of bluish green and extend far into the ultra violet, which though invisible to the eye, extend for a distance beyond the visible several times the length of the visible spectrum.

If it were not for the fact that ordinary optical glass is practically opaque to these ultra violet rays, we would be let in for a tremendous lot of complications with invisible lights, which could fog the film without visible knowledge on our part. Most of us have a hard enough time to keep from fogging the film as it is, without having to take precautions against an invisible enemy, such as the X-ray photographer has to contend with. The X-ray photographer or radiographer, as he prefers to be called, has either to keep the photographic materials at a long distance from his *Crookes* tubes or to wrap them carefully in sheet lead.

The invisible rays at each end of the spectrum are intensely interesting subjects to study and the readers will do well in their spare time to get some popular books on physics, and read up the subject of light, where they will find fascinating facts that have no room here.

By means of certain dye chemicals, it is possible to sensitize ordinary emulsions so that they are sensitive not only to all the visible colors but to the infra-red as well. Sir W. W. de Abney has even photographed a kettle by the infra-red rays emanating from boiling water contained therein. Radiant heat and infra-red are practically synonymous and interchangeable terms.

Professor R. W. Wood, of Johns Hopkins University, one of the most distinguished of American physicists, has attracted much attention recently by ingeniously photographing the common objects about us, as well as the planets, by these invisible rays. As has been stated, glass is opaque to ultra violet light but quartz and rock crystal are as transparent to them as is glass to ordinary light. Therefore to make photographs by ultra violet light, it is necessary to use a filter or screen to keep out the visible light just as one uses a yellow screen with orthochromatic plates to screen off the blue rays to which these plates are also sensitive.

Silver foil and bromine vapor confined in a rock crystal cell are opaque to visible rays, but transparent to ultra violet. Professor Wood also discovered that a black dye called nitroso-dimethyl aniline possesses this property.

For the infra-red or heat waves a glass lens will serve. Again it is necessary to screen off the visible light, which can be done with pitch or thin sheets of vulcanite. A number of these interesting photographs by Professor Wood were published in the Popular Science Monthly.

It may puzzle some readers to know why we distinguish between visual and actinic rays if all the actinic rays with which we are concerned are also visible. The reason is this: The blue and violet rays which comprise the actinic rays produce the strongest effect on a photographic emulsion and the weakest effect of any of the visual rays on the retina. Therefore when we focus on the ground glass we are adjusting the image by the strongest visual or the yellow rays and we are unconsciously disregarding the actinic or blue image, because it is overpowered and quenched by the more visible yellow rays. Although it may amount to considerable when the picture is magnified on the screen, the difference is so slight that it requires a powerful focusing glass and an extremely fine-grained ground glass to perceive it with the eye. Suppose the actinic and the visual focal planes were 2/1000 of an inch apart, about the thickness of a thin cigarette paper, by theoretical calculations it would appear to produce a blurring more than an inch in width in any sharp outline on the screen with a sixteen foot picture, considering the lens to have been used at F 3.5. Actually, for several reasons which have to do with the theory of development and light dispersion, it would be much more.

Ordinarily we would consider the edge of a cigarette paper as defining a sharp line, and yet the visible color fringe in the image on the ground glass for this same amount of error in correction would be only six ten thousandths (6/10,000) of an inch or less than one third (1/3) as thick as the cigarette paper.

Suppose, on the other hand, that a lens is absolutely correct and you are taking a scene which requires F 3.5 aperture and your error in focusing is two one-thousandths (2/1000) of an inch, or less than one-third (1/3) the thickness of the film, the amount of blurring will be the same.

With the lens stopped down these errors are reduced proportionately, but with a good lens, properly focused, you should get just as sharp a picture of objects at the same distance at F 3.5 as at F 16.

Do not misinterpret this statement to mean depth of focus. It means that at F 3.5 and the lens focused at sixteen feet (16 ft.) all objects in the range of the camera and sixteen feet (16 ft.) from it, should be just as sharp as those taken at F 16, but it does not mean that any object closer or farther away than sixteen feet (16 ft.) with the lens set for that distance will be as sharp at F 3.5 as at F 16.

Instead of using a ground glass or a piece of film for focusing, get a piece of first quality lantern slide cover glass or better still, get a piece of "optical flat" from the optician and cut it to the correct size to fit in the film rack at the frame aperture.

Get an optician to rule the glass in one-eighth to one-quarter inch squares making the lines as thin and fine as possible, and just deep enough to retain a spider-web line of fine black enamel or lampblack when rubbed over the surface of the glass. If you have a fine pointed glazier's diamond you can do this yourself. When you have finished, the cross lines should look as if they had been drawn with india ink and a ruling pen, but should be many times finer than could possibly be made with a pen.

Now you must have a focusing glass of fairly high power, preferably of the type known as a focusing loup, which is an achromatic magnifying glass set in a short tube with a screw thread for adjusting the focus. Place the ruled glass against the lower end of the loup with the lines outward and with it turned to the light, adjust the focus until the black lines are the sharpest. Now place the ruled screen in the aperture plate with the lines toward the lens and with the loup against the screen, focus the lens. You will see the image just as in the opera glass or telescope, except that it is upside down. When the image and the lines are in focus at the same time and the lines look like bars dividing the picture, your camera lens is in focus.

This is termed an aerial focus. As the human eye has a considerable range of focal adjustment, or "accommodation," as it is called, and could possibly focus on the aerial image even if it were not quite in the focal plane, the lines on the glass form a correct fixation point for the ocular focus and prevent its straying ahead or behind the proper plane.

If the focusing glass which you use for this is an achromat from a reputable maker and you can detect a prismatic fringe about any of the objects on which you are focusing, you may be sure that your photographic objective (your cinematographic lens) is not properly corrected. If so, return it to the maker. Don't try to take pictures with it.

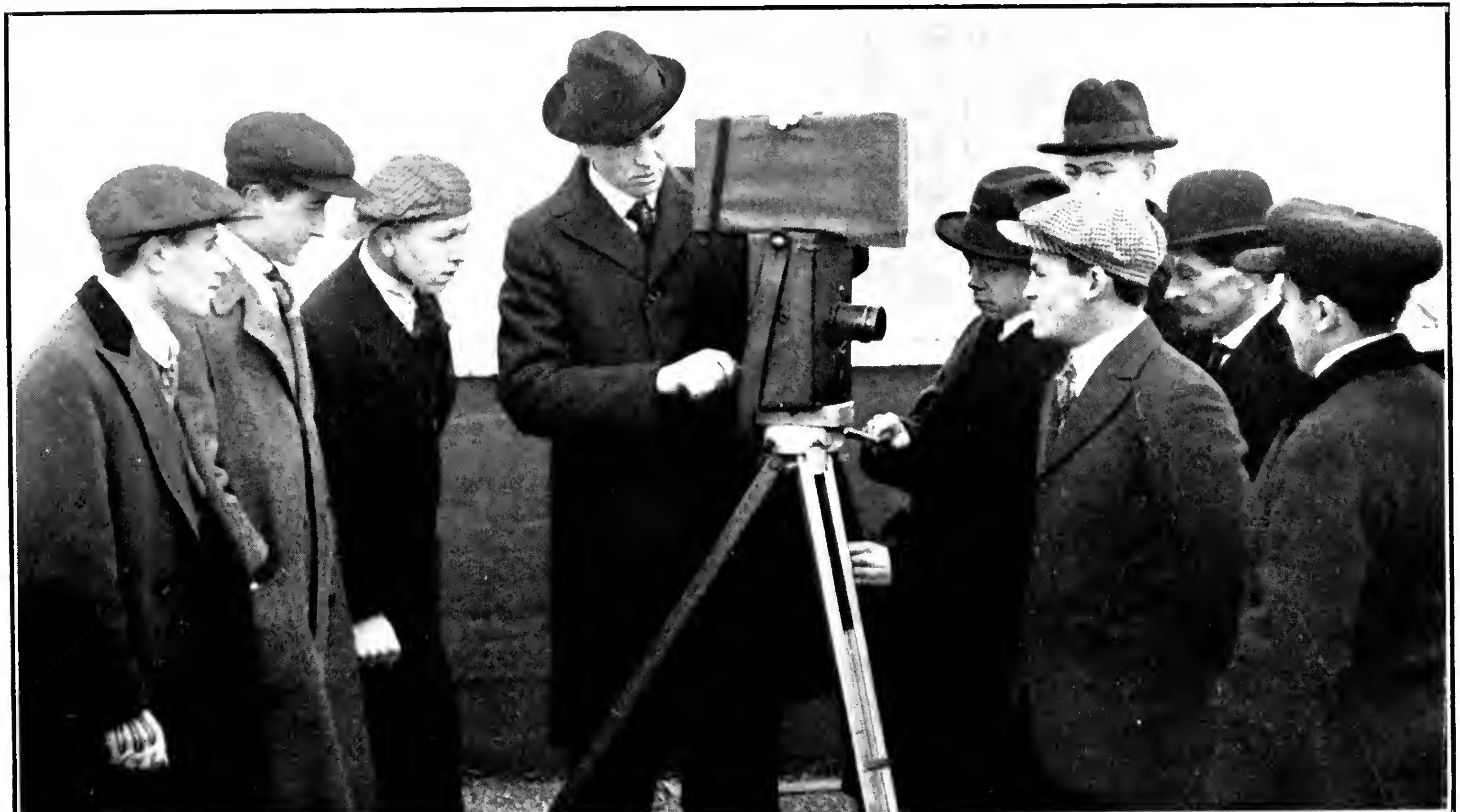
A microscopic focusing tube with which a needle point sharpness of focus may be obtained almost instantly is such a comparatively easy device for a cameraman to make, that it is remarkable that more camera workers have not provided themselves with such an instrument.

Practically every cameraman carries a focusing glass or magnifying loup of some simple character, but one who has used a focusing glass of medium high power will never again be satisfied with the rough approximation that is the best he can do with the ground glass and an ordinary loup.

It is remarkable how many cameramen regard an aerial image as something mysterious and beyond their comprehension. When the camera is focused correctly the image exists at the focal plane, *i.e.,* the frame opening, whether it be cast upon the film or ground glass or whether they be absent altogether. In focusing with the ordinary low power glass on the film or a piece of ground glass it is impossible, except by chance, to obtain a definition which is finer than the structure of the film or the granular structure of the abraded or ground surface of the ground glass.

The ground glass or film is an almost indispensable part of the cinematographer's outfit, it is true. Its use, however, should be for the composition of the picture and the placing of the side lines rather than as a necessary part of a focusing device. We cannot dispense with it if we have nothing more than ordinary focusing glass to depend on for sharpness of definition. If we attempt to view the aerial image with a low power glass, even though it be mounted in a tube at the proper focal distance for the eye, it cannot be relied upon unless a cross lined glass is interposed in the focal plane.

The human eye is a wonderful instrument and is able by a muscular contraction of its flexible lens to change the focal length



*(Photo by New York Institute of Photography)*

INSTRUCTING A CLASS OF FUTURE CAMERAMEN IN THE USE OF THE PATHÉ PROFESSIONAL CAMERA.

of the lens so that either near or distant objects may be brought automatically to focus. This is termed the accommodation of the eye; that is, the eye accommodates itself within certain limits to more or less diverging rays of light. If we attempt to focus on the aerial image at the aperture plate without providing a cross line at the focal plane so as to focus the eye at the proper distance we might find that the eye had accommodated itself to an aerial image having a position before or behind the actual focal plane. With the cross line in place, however, the image must be in the same plane as the cross line or it will be out of focus, so that when focus is obtained both the cross line and the image are equally clear and the image will be bisected by the cross line as in a surveyor's transit.

If, however, we take a step forward and increase considerably the power of the magnifying glass with which we examine the aerial image the slightest deviation of the image from the focal plane throws the lens system of the microscope so badly out of focus that it is much beyond the range of the eye's accommodation to bring it to a focus and we are thereby enabled to dispense with the cross line if we wish, as we have no further use for it.

It is imperative, however, in using a high power glass that some rigid mounting be provided by which it may be made certain that the magnifying glass be set always at the correct focal distance from the focal plane.

Resolved into its lowest principles a high power focusing device is a compound microscope mounted in a camera so that the image produced by the camera lens may be considerably enlarged. In the foregoing sentence the words "high power" are used merely as a term to differentiate a compound microscope from the magnification produced by a simple lens combination as found in an ordinary focusing loup. In reality, such a microscope is of very low power as compared to compound microscopes used for bacteriological examination.

Probably the cheapest and quickest way to obtain such a glass is to buy a student's ordinary compound microscope, which may be had for prices as low as two dollars and fifty cents to five dollars. Withdraw the tube containing the eye piece and objective and mount it directly in the camera.

If the construction of the camera prohibits the tube's being mounted permanently, it is an easy matter to provide a ring mount into which it may be slipped for use, taking care to provide a stop screw or ring upon the tube of the microscope, so that the instrument must come to rest at the proper distance from the aperture plate.

The first section of an ordinary brass draw telescope contains a similar lens combination and an old or second-hand telescope, if it can be purchased at a reasonable figure, will make an excellent focusing lens system.

If you are more ambitious you may purchase from one of the many excellent microscope makers an eye-piece and a low power objective and mount them yourself in a brass tube. An excellent set may be purchased for about fifteen dollars or even less and should you wish to go in for photo-micrographic motion pictures, you will be already provided with a lens set for photo-micrography. It must be understood that the higher the power of the magnifying glass the smaller will be the field. As any lens worthy of being fitted with a microscopic focusing tube must be truly anastigmatic, all objects within its range at the same distance as the object focused upon will be in focus also. The image through the glass presents also the advantage of being right side up, so that you will find your camera an excellent telescope which you focus with your focusing device instead of the usual magnifier.

The DeBrie camera is fitted with a focusing device admired by many cameramen. It gives the entire field of the aperture plate right side up and slightly magnified. It is always in place in the camera and the image may be almost instantly examined on the film by drawing out the eye-piece at the back and opening it. Such a glass may be made by using an objective of much longer focus than is ordinarily used in a microscopic combination. It gives such a low power that it is not safe to use without film or ground glass in the aperture on account of the accommodation of the eye, as previously explained.

A dodge to use in this case is to perforate the film and turn back until the hole is in the centre of the aperture plate, when the edges of the hole will serve the same purpose as a cross line. Unfortunately, unless the perforating device is correctly placed in relation to the frame line turning back will not bring it into correct position.

For the ordinary sized camera one may use for a DeBrie type of glass, the lens combinations from two achromatic loups of about one inch focal length, using one for the objective and one for the eye-piece.

With such a low power objective the distance from the aperture plate can be varied considerably, but is best determined experimentally to suit the distance from the aperture plate to the back of the camera.

It is well to arrange to have the eye-piece project beyond the back of the camera; otherwise it is hard to get the eye close enough for proper inspection.

For the first type of glass described a ½ or ¾-inch objective is of ample power and the eye-piece should be at the other end of a six or eight-inch tube or a longer one if the size of the camera makes it necessary.

This will bring the objective within an inch of the aperture plate. To find the exact focus, cut a piece of clear glass the width of the film and mark it with a rub of emery cloth on one side; lay this in the aperture plate with the scratched side toward the lens, remove the lens and with the camera turned toward the light and the glass in the aperture plate securely in position focus the microscope on the scratches on the glass. This is the position in which it must be fastened for focusing.

With the DeBrie type of glass, place the eye-piece on a stand at the distance from a piece of printed paper equal to the distance from the aperture plate in your camera to the point where you wish the eye-piece to project at the back. Move the objective back and forth in a straight line between the eye-piece and the printed paper. When you can bring the image of the type to a focus through the two lenses their separation is the length of the tube you will need for mounting them.

The degree of definition required in motion picture negatives is far beyond that usually necessary in an ordinary photograph. The screens are too great for accurate work, especially where the source of light is not of great strength.

A strip of glass or film the same width as the cine film, and two or three inches long is an almost indispensable part of the cameraman's outfit. It is slipped into the film track over the aperture opening and used in conjunction with a focusing loup or magnifier for obtaining an accurate focus.

Especially fine specimens may be made by the cameraman himself by following these directions, which are adopted from methods described in *The British Journal of Photography.*

Carborundum powder may be relied upon, if the finest and purest quality is used, to produce a first-class focusing screen in a very short time. With the exception of the powder, the only thing wanted is a "rubber," which consists of a piece of glass fixed with cement to a block of wood, which serves as a handle. In use the glass or film to be ground is wetted, a little powder is thrown upon it, and then the rubber is brought into play. Of course, the surface of the rubber becomes ground as well as that of the plate, and when it is in this condition it works at its best. The time required depends on the size of the rubber. Using one about 2 inches by 1, a 4 x 5 screen can be completely and perfectly ground in five minutes or less. It is best to grind a large piece and cut out the best sections for use.

A most useful application of the "rubber" is for grinding the backs of lantern or stereo slides. The former are sometimes, and the latter nearly always, all the better for being on ground glass, yet transparency plates on ground glass are not always available. A second cover glass is the usual expedient, but this adds unnecessarily to the weight and thickness of the slide. In view of the possibilty of wet and dirt getting on the film side of the plate during the grinding process, it is very advisable to formalin, dry and varnish the slide before grinding. Put the slide in a printing frame, glass side out, and grind with a small rubber. Take care that the slide is well backed up, and that the springs are strong enough to hold it up against the rubber. It can easily be packed up with a few spare or spoiled plates, or with cardboard, and then there will be no fear of the plate giving from the rubber, and so letting wet in under the frame rebate. When ground, the glass is cleaned while still in the frame, and on removal the film side should be found to be perfectly clean.

A series of three screens for general and special work is obtained as follows: Take three pieces of negative film and immerse them without any exposure at all in any non-staining developer free from bromide. At the end of twenty minutes remove two pieces from the developer, and fix and wash them in the usual way. At the end of twenty minutes remove the third piece from

(*Courtesy of the Universal Film Company*)

HELPING TO GET THE PUPS IN FOCUS.

the developer, and fix and wash that also. Next, iodize this third piece together with one of the others in a solution of iodine in potassium iodide. When the action is complete, rinse the pieces and bleach them in dilute ammonia. Then wash and dry. Finally, take the remaining film and immerse it in a solution containing ten grains of potassium bichromate, and five grains of hydrochloric acid to every ounce. When the chlorizing action is complete, rinse the film and put it into a fresh plain hypo fixing bath for ten minutes; then wash well and dry. You now have three screens of different degrees of density.

No. 1 is a dense iodide screen, No. 2 a thin iodide screen, and No. 3 a thin "chromium" screen. No. 1 screen will be an excellent substitute for the ground glass in all ordinary work. It can be used without a magnifier or with one, and in either case it will show detail that would not be visible on the screen of ground glass.

No. 2, the thin iodide screen, cannot well be used without a magnifier, but while it is too nearly transparent to permit focusing with the eye alone, it shows enough grain to render the use of the magnifier easy. There is no accommodation difficulty, and the detail visible on the screen is a revelation to those who have never used anything but ground glass. This screen is of special value for indoor work, such as architectural interiors and copying.

No. 3, the chromium screen, is quite useless without a magnifier, being almost transparent to the eye. But with the magnifier a very fine grain becomes visible, and as it is perfectly easy to keep this grain and the image in focus at the same time, there is no accommodation difficulty. This screen is a substitute for clear glass, and is especially adapted for copying and for low-power photo-micrography. For high-power work it does not seem possible to find any good substitute for clear glass, but with moderate powers the No. 3 screen seems to show almost as much detail as the clear glass, while it has not its disadvantages.

The screens can be ruled in pencil or with fine cuts to give datum marks. A cross ruling of fine cuts made with a lancet may be used but this is only a matter of personal choice. The surface is somewhat readily abraded in the case of No. 2 and No. 3 screens, hence they should be used carefully. It must be remembered that no fine grain screen shows such a bright image as ground glass. In comparison the image looks dull, but this is a very minor matter, and the extra detail visible more than compensates for the loss of brightness.

Douglas Carnegie, writing in reference to the fine focusing screens made according to the formulae given above, says that though the latter give much more detail than ground-glass screens, yet they labor under the disadvantage that, with the exception of a small portion of the image which happens to lie in the neighborhood of the line joining the eye with the optical center of the lens, the image as a whole is much dimmer than in the case of the coarser ground glass screens, and, therefore, the eyes must be very carefully shielded from extraneous light, in order to permit of the composition and proper centering of the picture on the screen.

A novel screen is made as follows: A plate which has been exposed in the camera to a uniformly lighted sheet of paper is developed, fixed, and then placed in a bath of hydrogen peroxide acidulated with sulphuric acid. The bath is warmed to a temperature of about 20 degrees centigrade. In a short time the hydrogn peroxide removes the developed silver and concomitantly some of the gelatine in which the silver was embedded, leaving the remaining gelatine in a very faintly opalescent condition. The plate is now washed, treated with Farmer's reducer if it still looks brown, and dried. A screen so made has just enough optical irregularity to prevent the image being viewed through it, but not enough to militate against the presentation of a very fine detail in the focused image. There is sometimes failure to get a good screen by this process even when observing the same conditions that led to satisfactory results in previous trials.

A method of focusing, which avoids the trouble of "accommodation," which takes place when a magnifier is used with a focusing screen containing a transparent patch, is as follows: The screen used is a plate of glass fairly heavily ground all over, with a view to a bright general image, with the exception of a small circular central spot, which is left transparent. Such a screen is made in a few minutes by sticking a small washer on the center of the plate and grinding round this with carborundum powder, using as a muller a small piece of flat glass to which a slab of wood has been stuck to act as a handle. A small strip of tinfoil cut with a razor is stuck across the transparent portion of the screen. On the unground surface of the glass, just over the region of the transparent disc, a small adjustable magnifier of about ½ inch focal length is permanently fixed. The magnifier actually used was constructed from a cheap linen tester. The magnifier is focused on the edge of the tin-foil slip and set. It is not necessary to bestow any especial care on this adjustment. The lens is now racked until there is no apparent relative movement, parallax between the edge of the slip and any selected portion of the image seen through the magnifier when the eye is moved laterally across the field of view of the magnifier. This being the case, the lens image must of necessity lie precisely in the plane of the front surface of the screen. The function of the magnifier here, it will be noticed, is not to aid the attainment of that very uncertain condition, the exact position of clearest visualization of fine detail in the image, but simply to magnify a displacement. Hence there can be no complications arising from unavoidable accommodative changes in the eye.

The delicacy of this method of focusing is quite surprising; the most insignificant rotation of the focusing pinion from the position of zero parallax produces an easily perceptible relative displacement of the tin-foil edge and any selected image detail.

## Chapter VII

# PREPARATION FOR THE DAY'S WORK

MOST studios, up to a recent date, have been in the habit of furnishing the cameraman with all of his apparatus, and the best of them have maintained mechanical departments where such apparatus could be kept tuned up to the best mechanical perfection. The increasing demands upon the limited facilities of these machine shops for the repair of factory machinery, such as perforators and printers, coupled with a shortage of the necessary number of cameras, has retarded the work of camera repair and put into the background that primary requisite for the making of good negatives, a camera in perfect mechanical condition. So bad has this situation become, and the number of new studios which have started without even a pretense of a machine shop, that many of the more conscientious operators have purchased their own outfits and fitted them up at their own expense in order to have the facilities for turning out work of which they need not be ashamed.

The cinematographer must learn to be on the job constantly, to be prepared always for whatever emergency may arise, to have his camera loaded and ready to shoot when the scene is rehearsed, to use judgment and tact, to keep in mind the dignity and importance of the proper photographing of the picture, and to insist, as far as consistent with holding his job, that he be furnished with every reasonable facility for the production of the best quality of work.

He should make it his business to know whether it is for the best interests of the company to sacrifice a small percentage of photographic quality and take pictures in a waning light in order to finish with a large cast so that it will not be necessary to call them a second day, or whether the improvement in better negative will justify the expense involved in quitting when the light is getting poor and hiring the large cast again the second day. Confer with your director at the close of work each day and schedule your work for the next day. It does away with the

(*Courtesy of Goldwyn Film Company*)

CAMERAMEN AND ELECTRICIANS AT WORK ON "THE BELOVED TRAITOR."

haphazard method; it saves money for the concern, and, if you train yourself to do more, you can earn more.

Let us assume that the cameraman reports for duty on a certain morning. He will be assigned to a director who usually says: "We work on exteriors today," or "Set up in the studio," and will designate a certain scene. This is about all the information the cameraman will get. He is supposed to know exactly what to do. If he follows our instructions he will not be in a moment's doubt. Go to the office or stock-room and ask for 1,600 ft. of stock (negative stock), be sure it is perforated—that is to say either ask whether or not it is perforated or look for a mark on the can stating this.

In some studios it is customary to draw enough film for several days or a week's supply, but this can be ascertained by judicious inquiry.

Another important matter is to be sure to ask for X-back film if the weather is cool. Most studios begin using X-back film about September 1st and continue doing so through the winter until about May. In California, X-back is seldom used as the weather does not get cool enough to cause electrical markings, or "static" as it is called.

X-back is film which has been coated on the back with a gum or resinous substance by the manufacturer. This backing tends to keep the celluloid base of the film from actual contact with the camera as it moves through and therefore prevents the friction from acting on the celluloid and producing electrical flashes in the camera. It is always safer whenever there is the slightest doubt about the weather being cool enough for "static" to ask for X-back. It costs the studio no more and the emulsion is exactly the same and all the backing washes off in the first few minutes in the developing solution. Many workers use it the whole year round.

Anyone who has ever seen a fine scene utterly ruined by a series of fern-like black lines—static—which magnify on the screen until they look like the branches of a tree—will appreciate the advantages of using X-back film for X-back certainly does prevent static. I have never been bothered with a foot of static on X-back although on days only slightly chilly I have had some wonderful criss-cross patterns on films when I did not use it.

After getting the film, go to the dark room which you should also ask for and load your magazine by the light of the ruby lamp therein.

Allow about a foot of film to project from the slit in the magazine.

In the Pathé magazines there are two slits. The proper method to load this magazine is so the ribbon of film will exit through the left hand slit when the magazine is laid on the table with the two slits at the bottom facing the operator. It must also go through the slit with the emulsion of the film facing the roller which is just inside the slit.

In all cameras the magazines must be so loaded that the film will leave the magazines with the film in such position that the emulsion side will be TOWARD the lens IN ALL CASES.

When you have loaded four magazines be sure you have at least one more empty to take-up the film you are going to expose. It is safer to have two empties on hand. If your work is to be exterior it is a good idea to pack a small changing-bag along. It takes up very little room and is of great value in case of a "buckle" or "twist" in the film inside a magazine, as sometimes happens.

See that the camera is properly oiled. This means that every part that moves or rotates on another must have a thin film of oil upon it at all times. The best oil to use on cameras is sperm oil. The old fashioned sewing-machine oil is excellent. The much exploited patent oils that are advertised to clean, prevent rust and pretty near anything from wear and tear to hookworm, are useless. They contain little or no "body" and a camera lubricated with "4 in 5" or "6 in 1" or similar oils will wear out in a few months.

On the other hand heavy greasy oils tend to gum up and collect dust. Vaseline or cup grease should never be used on anything, not even gears in a camera. Graphite is dangerous as it clogs oil holes and prevents oil from reaching hidden bearings.

Next be sure your still camera shutter is working and the holders loaded. The cameraman is expected to take "stills" of his scenes and it is not considered necessary to tell him to bring his "still" along. He always takes it along whether needed or not. A dozen plates or cut films are sufficient and all that will be required.

Do not forget a focusing cloth. No tripod will be required for the "still" as they are furnished by the studios with a screw base to fit the motion picture camera-tripod. The usual size still cameras furnished are 8 x 10.

Try always to be on time. If the director calls his people for nine o'clock be ready and waiting in the studio auto or wherever you know your place to be exactly at that hour. A call for nine o'clock does not mean that you are to come drowsily into the studio at that hour and then hold everybody up until you get film loaded, camera packed, etc. Be always ready on the job and you will have won nine-tenths of the battle of installing yourself as a valuable man in that studio.

Most studios provide assistant cameramen to take care of the camerman's equipment, but he is a wise cameraman who loads and unloads his own magazines and sees that everything is ready himself. It is proper and advisable to allow the assistant to carry the equipment and load it in the auto but it is highly advisable for the cameraman himself to take a last look to see that all is there. I have repeatedly found that when an assistant reported "all is on board" some small unimportant piece like the camera itself was peacefully reposing in the dark room.

A good assistant in whom the cameraman can place absolute trust—even to the confidence of his position—would be a boon indeed but, I greatly fear, "there ain't no such crittar." Long before an assistant becomes so perfect he has worked his way into a better position. But the assistant is important in his way. He carries the heavy pieces and the reflector, holds the reflector at the angle which the cameraman sets it, holds up the slate with the number on it to photo at the end of the scene, helps steady the camera in high winds, hands the plate holders for stills to the operator, sets up and takes down the cameras and makes himself useful in many ways.

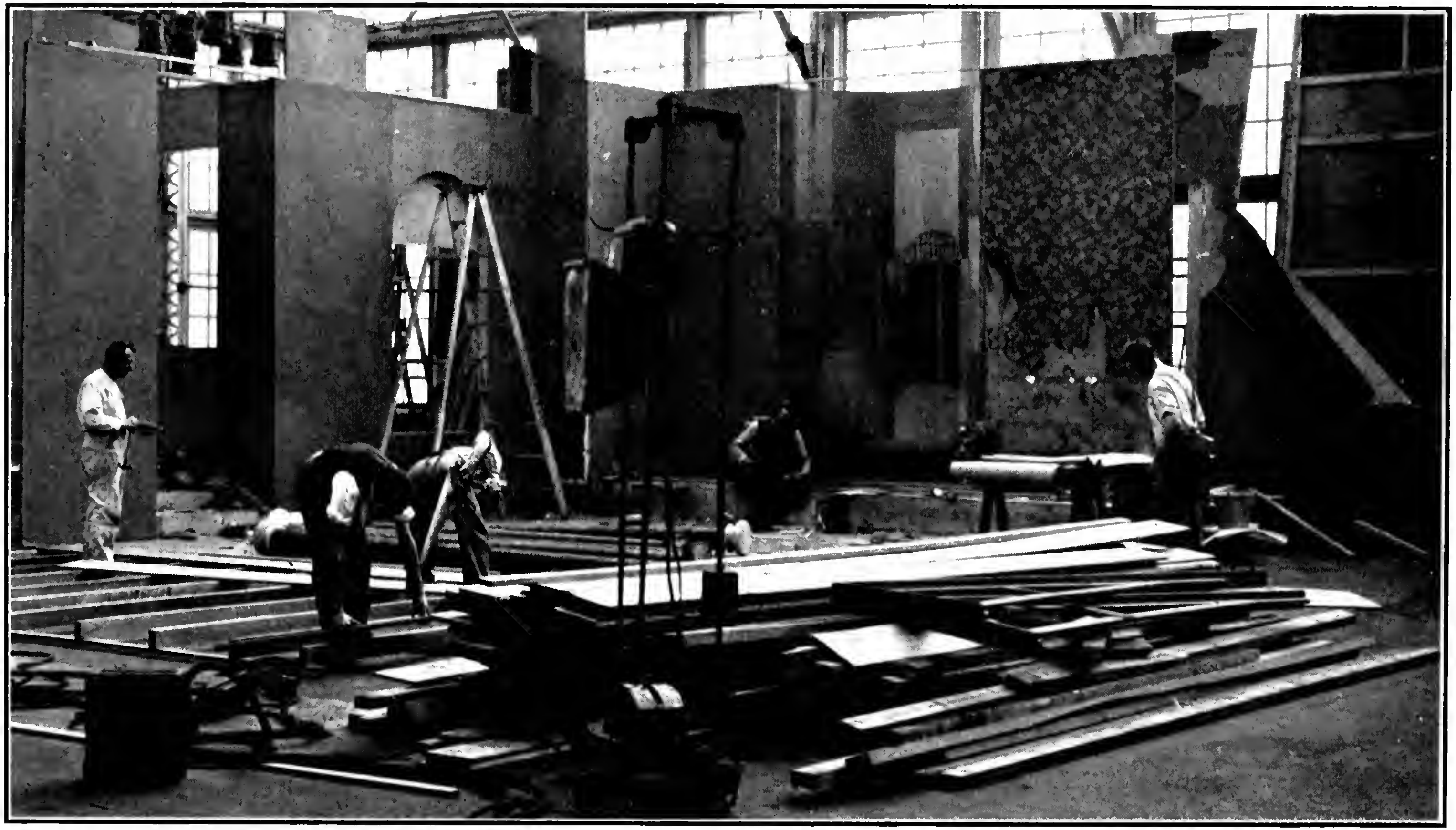
Do not hurry with your work of threading-up camera or getting set. Be sure everything is correctly and carefully done. Never say "ready" until you are really sure you are.

Upon returning from "location" it is advisable to take the rolls of exposed film out of the magazines, can them and see that they go to the developing room at once. They are then out of your hands and you will feel better satisfied than if they lay in the magazines over night. If anything happens to the film then it is not your fault.

When leaving your dark room for the night be sure the ruby and other lights are out, the camera and magazines on the table or shelf—NEVER ON THE FLOOR—the door locked and key in your pocket.

Experience in photographic work is the best foundation for a cameraman's job. The ranks of the cinematogrophers of the present have been recruited from strange places in many instances. Most of the best men have worked their way up from some film factory position—they have worked in dark rooms, they have finished stills, but at the same time they were ambitious. Most of them had a camera or kodak of their own and they took their little cameras out on Sundays and made snapshots. During the evenings of the week they developed and printed them. They got books on photography from the public library and bought photographic periodicals and they read and studied them. While they were at work in the film factory they learned all they could from their fellow workers. They earned each promotion by hard work and study, and at last, after a thorough apprenticeship, they arrived at the position of cameraman. But if they became good photographers they did not stop when they had learned to thread the camera and turn the crank; there were lots of things to be learned about lighting and about artistic composition and posing. There was much to learn about lenses, about trick work and visions, and then beside all this and just as important, too, as the technical knowledge is the co-operation and co-ordination with the work of the director. It is essential to the best work that the photographer be able to catch and instill into his picture the same spirit and motive which actuates the director who produces it. Unless the photographer understands and appreciates what his director is endeavoring to do, he cannot produce the best work.

From the ranks of the newspaper photographers have come some of the best topical news cameramen. Theirs is practically a separate branch from the work of those who make dramatic pictures, and while numbers of them have gone in very successfully for studio work on dramatic pictures the qualifications which make for the success of a topical film weekly photographer are



*(Courtesy of the Goldwyn Film Company)*

AN INTERIOR SET IN COURSE OF CONSTRUCTION.

mostly different from those of the photographer who works with a director in the production of staged stories.

Many of the men who are now turning out productions have learned as camera boys or assistants to cameramen and their success has depended much upon the preceptors under whom they worked. Most of them realize the handicap imposed upon them by their lack of laboratory experience, and only by serious study from whatever sources available to them have they been able to overcome their lack of training. Unfortunately, there are many such at work taking pictures now who lack this training so necessary to the production of the best work.

The relations between the cameraman and the director of a picture are rarely as intimate as they should be. The production of a film in a proper and fitting manner is one that requires the closest co-operation between *every* factor of the working forces and the cameraman and director are the two greatest factors in this production. When they do not understand one another; when they work at cross purposes, it is evident that the production must suffer.

The director is at the mercy of the cameraman for the proper interpretation of his ideas upon the screen. Each necessarily imposes all of his own limitations upon the other and it is only through a thorough understanding and the closest co-operation that these limitations are prevented from conflicting with the perfection of their work.

There are many cameramen who are jealous of allowing their director to learn what he ought to know about photography and the limitations of the camera and there are also many directors who are too prone to regard the cameraman as a mere mechanical accessory, possessing little or no brains. When these conditions obtain neither can respect nor have any great consideration for the ideas of the other, but when the director realizes that his cameraman is a master of his craft, understands and knows what he can do with the camera and when the cameraman knows and realizes that his director knows his business, has a concrete idea as to what he wishes to portray upon the screen and knows that what he wishes to portray can be photographed so as to interpret his idea to a spectator, then the cameraman and the director have reached an understanding under which they should be able to produce very nearly perfect pictures.

Both cameraman and director should realize that not only are they being paid a salary to produce the best of which they are capable, but they should also have a sense of the dignity of the task which they are doing. Even the production of a rough-and-tumble slap-stick comedy has a dignity attached to its production. "Anything worth doing is worth doing well," although a trite saying, still holds a world of meaning and though well worn by long usage, is a motto which might well hang above every director's desk and in every cameraman's room.

Too many cameramen and too many directors, as well, fail to understand why they do not make a greater success, when they are satisfied with any old thing and perform a task just sufficiently well to enable them to "get by."

I have met many directors who seem to think the best training in stage craft and drama can be obtained from all-night poker parties and the infiltration of booze. I know cameramen who have kept their photographic eye in practice by sighting along the billiard cue and who get the largest part of technical training from the comic supplements of the Sunday newspapers. Yet they wonder why some cameramen are called "crank turners."

Perhaps some of you boys think this is rather drastic stuff, that I slam it in too hard once in a while, but mark this—the quiet fellows who are drawing down the real figures on their pay checks on Saturday night are the boys who put brains into their business, who are "Jerry on the job" and "Johnnie on the spot" when it comes to producing the goods. What they don't know they learn somehow. They don't belong to the clique of those who know too much to learn any more. They were not too proud to exhibit their ignorance when it came to a question of something they didn't know, but went and asked someone who did know, or spent the necessary time to dig it out for themselves from some text-book where they could find what they needed.

There has been much talk recently of overcrowding the profession of cameramen thereby bringing about a general reduction in salaries. The man who knows his business does not have to worry; the man at the top will always get the top-notch salary. If you have the determination and stamina to learn and apply what you should know, you will have little occasion to worry about any reduction in salary. One of the best indications of this is the fact that there are quite a number of cameramen today who are drawing larger salaries than the directors for whom they take pictures, and although it is dangerous to prophecy, I am confident enough of the dignity and worth of the profession which bears the commonplace name of "cameraman," to predict that more and more will come an equalization of the salaries of cameramen and directors.

Not alone to the director belongs the distinction of creative ability in the production of pictures. With the raising of the standard of craftsmanship, ingenuity and knowledge required of the cameraman, comes greater regard. The worth-while cameraman is able to endow the director's ideas with artistic and pictorial worth.

## Chapter VIII

# HOW TO PREPARE PHOTOGRAPHIC SOLUTIONS

By J. I. Crabtree

(Research Laboratory, Eastman Kodak Co., Rochester, N. Y.)

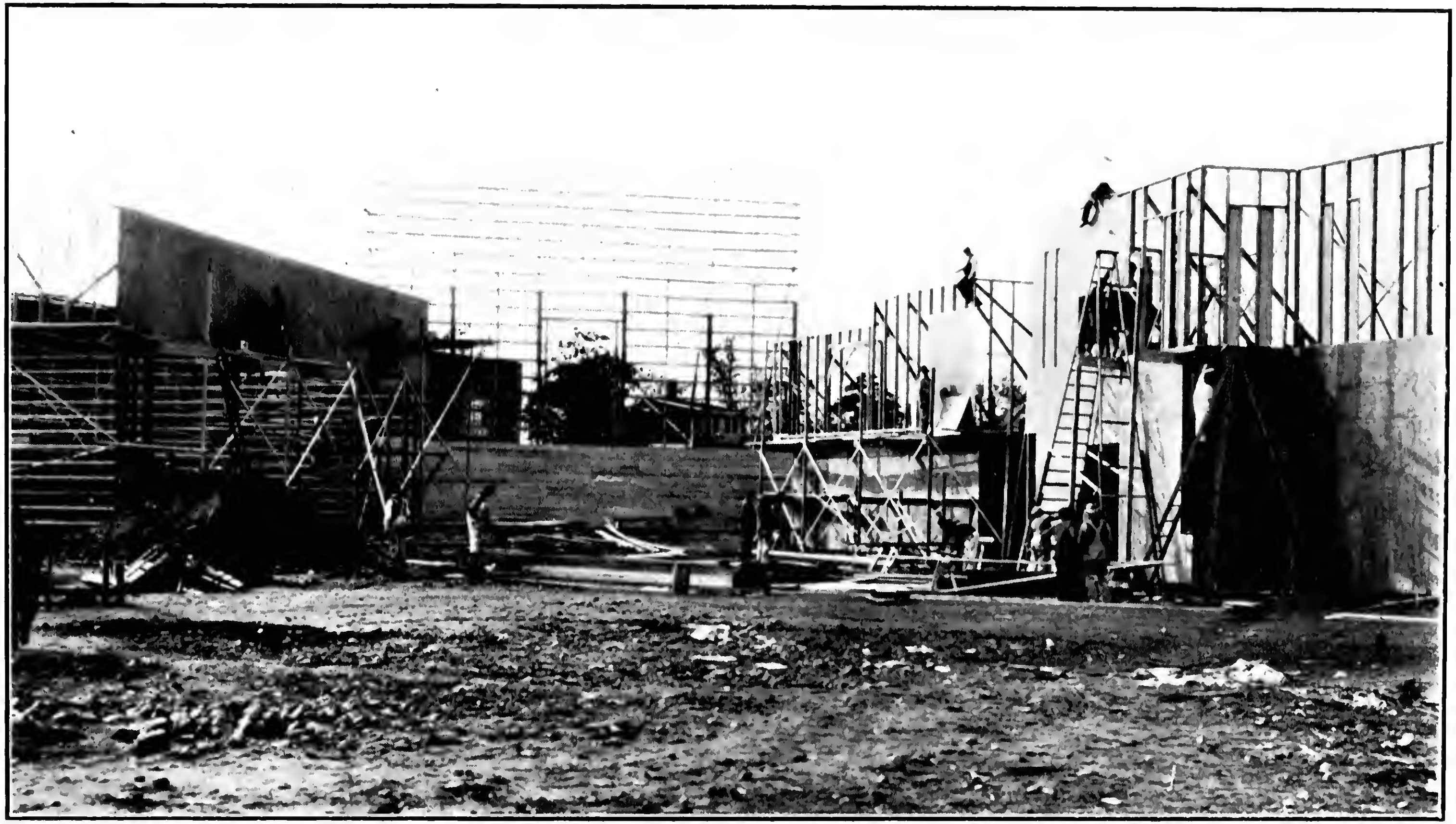
ALTHOUGH the majority of amateur photographers prefer to purchase photographic chemicals in a condition ready for use, in the case of advanced amateurs, professional photographers and motion picture producers who use chemicals on a large scale, it is customary for them to prepare the various photographic solutions from the component chemicals.

In order to be able to prepare correctly any and every solution used in photography a knowledge of the properties of the chemicals used and of the chemical reactions involved during the mixing is essential, though by adhering strictly to printed directions it is usually possible for an unskilled worker to prepare the developing and fixing solutions as generally used. However, instructions for the use of various materials differ. For example, in the case of some developing formulae it is recommended to dissolve the Elon first, while according to others the sulphite should be dissolved first. Both methods may be right, but if a systematized method of mixing is followed, and especially if the photographer has a knowledge of the reactions involved, then he can proceed to mix any developing solution with confidence, and what is more, he will be able to locate the trouble if for any reason the solution does not work correctly after mixing.

It is the purpose of the author to describe in as non-technical language as possible the systematized method of preparing solutions now practiced in the Research Laboratory of the Eastman Kodak Company.

### Definitions

A solution of any kind is obtained by dissolving a solid or a liquid in another liquid (or solid). The substance being dissolved is called the solute and the liquid in which it is dissolved is called the solvent. The extent to which the solute is soluble in



(*Courtesy of Goldwyn Film Company*)

CARPENTERS PREPARING AN EXTERIOR SET FOR "THAIS"

the solvent is called its solubility and when the solvent will hold no more of the solute it is said to be saturated.

The degree of solubility of any chemical depends on the nature of the solvent and on the temperature, which should always be stated.

If a saturated solution is cooled down to a lower temperature, crystals usually form which settle out until the saturation point is reached at that particular temperature, though in the case of a substance like hypo, if all dust is excluded, crystals do not separate out on cooling, and a so-called super-saturated solution is obtained. However, if a small crystal of hypo is added to the solution, crystals immediately form and continue to grow until the saturation point is reached. The best method of preparing a saturated solution therefore is to dissolve the chemical in hot water, cool to room temperature with shaking, allow to stand, and filter.

### Meaning of "Water To"

When a chemical is dissolved in water the volume of the solution is usually greater than that of the water used, because the particles or molecules of the chemical occupy a certain space when in solution. In case two liquids are mixed, the final volume of the liquid is not necessarily equal to the sum of the volumes of the liquid is not necessarily equal to the sum of the volumes of fifty volumes of alcohol when added to fifty volumes of water at 70° F., produce ninety-seven volumes of the mixture and not one hundred. Moreover, equal weights of different chemicals do not occupy the same volume.

In photography we are concerned only with the weight or volume of each chemical in a fixed volume of the solution, so that when mixing, the chemical should be dissolved in an amount of water appreciably less than that called for in the formula and then water added up to the amount stated.

### The Metric System of Weights and Measures

In photographic practice, solids are weighed and liquids are measured either by the metric or the avolrdupois system.

Although a large majority of photographers use the avoirdupois system of weights and measures, this system is inconvenient and complicated as compared with the metric system.

The metric unit of length is the meter (which means measure). The meter is divided into one hundred parts called centimeters, abbreviated to cms.

The unit of volume is the cubic centimeter, written cc., or ccs. in the plural, 1000 ccs. being equal to one liter or 1 L. The cubic centimeter is sometimes termed a milliliter or ml. (meaning one thousandth part of a liter) though the term cc. is satisfactory for photographic purposes.

The unit of weight is the gram which is the weight of 1 cc. of water at 4° C., at which temperature a given volume of water weighs the most. The gram is written Gm. for short, the capital letter G being used to differentiate between Gms. (grams) and grs. (grains).

For compounding photographic formulae only Gms., ccs., and liters are used, and fractions are always expressed as a decimal just as in the case of the U. S. currency which is a metric currency. The beginner should therefore think of grams and parts of a gram as if they were dollars and cents. Thus 5.35 Gms. corresponds to $5.35 or 5 35/100 dollars.

### The Avoirdupois System

In photography the following table is used:

| *Weight* | | *Volume* | |
|---|---|---|---|
| 437 grains | = 1 ounce | 60 minims | = 1 fluid drachms |
| 8 drachms | = 1 ounce. | 8 fluid drachms | = 1 fluid ounce |
| 16 ounces | = 1 pound | 480 minims | = 1 fluid ounce |
| | | 16 ounces | = 1 pint |
| | | 128 ounces | = 1 gallon |

### The Conversion of Formulae

Every photographer should be able to convert a formula given in avoirdupois terms into metric equivalents without reference to a table. It is simply necessary to remember that—

| | |
|---|---|
| 15 grains | = 1 Gm. |
| 1 ounce | = 30 Gms. |
| 1 fluid ounce | = 30 ccs. |
| 1 gallon | = 4 liters |

from which it is readily deduced that—

| | | | |
|---|---|---|---|
| 2 pounds | (roughly) | = | 1 kilogram |
| 1 ounce | " | = | 450 grs. |
| 1 pint | " | = | 550 ccs. |
| 1 cc. | " | = | 50 minims |

The foregoing conversion table is not strictly correct, for example one gram = 15,432 grs., 1 oz. = 28.35 Gms. and 1 fluid oz. = 29.43 ccs. In taking 1 Gm. as an equal to 15 grs. we are making an error of four parts in 154, or nearly 3%, but in photography an error of 5% in most cases is permissible. Thus if a formula called for 453½ grs., if this were cut to an even 450, the difference would not be detectable by photographic means, though if a quantity of 6½ grains were cut to 5 grs., then the error (20%) would be serious.

### Uniformity in Formulae

Formulae should always be given in both metric and avoirdupois equivalents, but in some cases the proportions are given for, say, 40 ozs., in one case and 1 L. in the other. Now, 40 ozs. = 1,200 ccs., so that the several quantities are not equivalent. This leads to error in case the chemicals are weighed out with avoirdupois weights and the solution made up to strength in a liter graduate, though if these quantities are given for 32 ozs. of solution which are equivalent to 960 ccs., or roughly 1 L., no serious trouble will arise if the above mistake is made.

The order in which the ingredients are given in the formulae is of importance. In some cases water is placed first, in other cases last, but since all developers are mixed with water, its position should be last in the formula. The ingredients should be given in the order in which they are dissolved, which is as follows: (1) preservative, (2) developing agent, (3) accelerator, (4) restrainer, (5) water to.

### Percentage Solutions

In photography two kinds of solutions are used as follows:

(a) A solid in a liquid.
(b) A liquid in a liquid.

(a) The misunderstandings which have arisen from time to time regarding the correct method of preparing solutions of a definite percentage strength is due to the fact that there are three ways of doing it. For example, we can make a 5% solution of potassium bromide as follows:

(1) Dissolve 5 Gms. in 100 ccs. of water.

(2) Dissolve 5 Gms. in 95 Gms. of water making 100 Gms. of solution.

(3) Dissolve 5 Gms. in a liter of water and make up to 100 ccs.

In case (1) we have about 103 ccs. of solution and in case (2) about 98 ccs. A chemist would use method (2), but method (3) is used when preparing photographic solutions. Method (1) is not used for the reason given above, namely, that equal weights of different chemicals do not occupy the same volume.

The percentage strength of a solution therefore merely indicates how much of the chemical is dissolved in 100 ccs. of the solution.

To prepare a 7% solution of potassium bromide, therefore, take 7 Gms. of the salt, dissolve it in a little water, and add water up to 100 ccs. If we now measure out 100 ccs. of the solution we have measured 7 Gms. of the solid.

In the avoirdupois system a 10% solution of solid is made by taking 1 oz. and making up to 10 ozs. with water. Converting these figures into Gms. and ccs. we have 30 Gms. in 300 ccs., or a 10% solution.

Strictly speaking this is not correct since 1 oz. = 28.35 Gms., and 1 fluid oz. = 29.57 cc., so that 1 oz. in 10 fluid ozs. is equivalent to 28.35 Gms. in 295.7 cc. or 9.6 Gms. in 100. The error involved, however, is less than 5% and for ordinary purposes is therefore negligible.

If a photographic solution is made by any of the above methods, 1, 2, or 3, the error involved is less than 5% and therefore negligible for ordinary photographic purposes, though since the correct method is the easiest, it should be followed.

Although somewhat of an anomaly, it is possible to prepare a 100% solution of a substance like hypo by dissolving 100 Gms. (which do not occupy a space of 100 ccs.) and dissolving in sufficient water to make 100 ccs. of solution.

(b) A 10% solution of a liquid in water is made by taking 10 cc. of liquid and adding water up to 100 cc.

### The Meaning of "Parts"

It is often recommended to dissolve, say 10 parts of a solid in 100 parts of water. Such a statement is meaningless because a solid chemical is weighed while a liquid is measured, though if the metric system is used (since 1 cc. of water weighs 1 Gm.) grams and ccs. may be considered synonymous with parts.

In the case of liquids, parts should be taken as meaning units of volume, and in the case of solids as units of weight. A "part" may therefore mean anything from a gram to a ton, or a cc. to a gallon so long as the other quantities are reckoned in the same units of weight or volume.

Thus:

| | | | |
|---|---|---|---|
| For use: A three parts | | A 300 ccs. | A 15 oz. |
| | may mean | | or |
| B one part | | B 100 ccs. | B 5 oz. |

If the avoirdupois system is used and the formula contains both solids and liquids, if ounces (liquid) and ounces (solid) are substituted for "parts," the error involved falls within permissible limits.

Problem:

Mix one gallon of solution according to the following formula.

| | |
|---|---|
| Sodium sulphite .................... | 10 parts |
| Pyro .............................. | 1 parts |
| Water to.......................... | 100 parts |

Now, one gallon equals 4,000 ccs. Therefore, dissolve 400 Gms. of sulphite in water, add 40 Gms. of pyro, and make up to 1 gallon.

### "Drops"

If a formula calls for, say 5 drops of a solution, this is a very uncertain quantity because drops of liquid vary considerably in size. The average drop from the usual dropping bottle or burette measures about 1 minim or a little less than one-tenth part of a cc., so that 5 drops may be considered as ⅓ cc. or 5 minims.

### The Hydrometer Test

Many photographers are accustomed to making up their stock solutions of hypo, carbonate, sulphite, etc., by means of the hydrometer. This method has the advantage that in case the hypo (say) has become moist and contains an unknown amount of water, a definite reading on the hydrometer will give a solution of the same strength as if perfectly dry chemicals had been used. When a stock solution is made from moist chemicals by weighing, the error caused by the presence of water may be as high as 25% or 50%.

The hydrometer method has the disadvantage that the adjustment of a solution to the required strength takes considerable time, the hydrometer reading does not convey an idea as to the percentage strength of the solution, while the hydrometer reading varies with the temperature. For instance, if a stock solution is made with hot water and this registers, say, 45 on the hydrometer, on cooling, the liquid may register 48 or 50. It is therefore absolutely necessary either to make all readings when the solutions have cooled to room temperature, or to prepare a table giving the variation of density of each solution with temperature.

## Usefulness of Per Cent Solutions

The great advantage of stating the strength of any solution in parts per hundred is that a definite mental picture is at once created of its relative strength while by means of a number of stock solutions it is possible to compound certain formulae by simply measuring out a definite volume of each solution thus dispensing with a balance. Supposing we have a 10% solution of potassium ferricyanide and of potassium bromide already at hand and it is desired to make up the following solution:

| | |
|---|---|
| Potassium ferricyanide............. | 6 Gms. |
| Potassium bromide .................. | 2.3 Gms. |
| Water to .......................... | 1,000 ccs. |

it is only necessary to measure out 60 ccs. of the ferricyanide solution, 23 ccs. of the bromide solution and add water up to 1,000 ccs. and the solution is made.

In the case of very concentrated solutions it is not always possible to use this method, though in view of the time saved and the accuracy of the method it should be applied whenever possible.

Suppose a formula calls for 0.1 Gms., it is impossible to weigh this amount accurately on the usual photographic scale, but by measuring out 1 cc. of a 10% solution, and adding this to the mixture, the problem is solved.

## Photographic Arithmetic

It is often required to mix up a quantity of solution much greater than that given by the formula, in which case the photographer must perform a very simple exercise in arithmetic in order to secure the desired result. The two following examples indicate the method of solution of such simple problems.

A. Mix 6 oz. of solution according to the following formula:

| | |
|---|---|
| Potassium ferricyanide.............. | 4 Gms. |
| Hypo ............................. | 10 Gms. |
| Water to .......................... | 100 ccs. |

now 6 oz. = 6 x 30 = 180 ccs. Therefore, we need 180/100 x 4 = 7.2 Gms. of ferricyanide and 180/100 x 10 = 18 Gms. of hypo. Dissolve these in a little water and make up to 180 ccs.

B. How would you mix 1 pint of a 7% solution of sodium sulphite?

To make 100 ccs. of a 7% solution we need 7 Gms. Therefore, to make 1 pint (500 ccs.) we need 5 x 7 = 35 Gms. To prepare the solution therefore, dissolve 35 Gms. of sulphite in water and make up to 1 pint.

## Dilution of Liquids

It is often required to reduce the percentage strength of a solution. For example: How would you mix two gallons of 28% acetic acid, from a supply of glacial acetic acid?

To make 100 cc. of 28% acid we need 28 ccs. of glacial acid.

To make 1 cc. of 28% acid, we need 28/100 ccs. of glacial acid.

To make 8,000 ccs. of 28% acid we need 28 x 80=2,240 ccs. of glacial acid.

Therefore take 2,240 ccs. of glacial acid and add water to make 2 gallons.

To dilute a solution three times we do not add three times the amount of water but twice the amount and so on. For example: One volume of solution plus 2 volumes of water = 3 volumes of solution, which is three times as weak or three times as dilute as the original.

## Stock Solutions

A stock solution is a concentrated solution to which water is added before use. In the case of simple solutions containing only one salt such as potassium bromide, sodium carbonate, etc., a 10% solution is most convenient because by multiplying the volume of the solution in ccs. by 10 we get the number of grams present in the solution. Thus 75 ccs. of 10% potassium bromide contain 7.5 Gms.

The limiting strength of solution which it is possible to make in any particular case depends on the solubility of the chemical, and as the solubility diminishes with temperature a solution should not be made stronger than a saturated solution at 40° F., otherwise in cold weather the substance would crystallize out. (The reader is referred to tables of solubilities given in most handbooks.)

A stock solution of sodium sulphite should be made as strong as possible (15% of the desiccated salt) because at such a strength the solution oxidizes very slowly and will therefore keep, whereas in weaker solution it combines with the oxygen in the air very readily and is then useless as a preservative.

## Apparatus

### *Scales*

For quantities up to 100 Gms. a double pan balance should be used and a larger one for quantities up to 1,000 Gms. For still larger quantities a platform scale weighing in pounds may be used, because large metric scales are not readily procurable. For preparing small amounts of sample developers a small chemical balance weighing in hundredth parts of a gram is necessary.

### *Mixing Vessels*

For small quantities of solution conical glass flasks are the most suitable. For larger quantities use enameled buckets. Earthenware crocks are usually unsatisfactory because when the glaze cracks, the solutions penetrate into the pores and thus contaminate any other solutions subsequently mixed in them.

A wooden stick or paddle is the best form of stirrer, but a separate one should be used for each solution so as to eliminate the possibility of contamination.

The paddle may also be used to measure out a definite volume of solution in a tank or crock by cutting notches in the paddle to correspond with definite volumes when the paddle is held vertically. Such markings are only applicable, however, to the par-

(*Courtesy of the Universal Film Company*)

MISS DOROTHY PHILLIPS PLAYING A DUAL ROLE IN "THE RIGHT TO HAPPINESS."

ticular tank or crock for which the paddle was graduated, so that a separate paddle should be used for each tank or crock unless they are of the same shape and capacity.

Chemicals should be weighed out and the solutions prepared in a separate room, and care should be taken when handling such substances as hydroquinone, resublimed pyro, potassium ferricyanide, etc., not to shake the finer particles into the air, otherwise they will enter the ventilating system and settle out on benches, negatives, and prints, and cause no end of trouble in the way of spots and stains.

### Weighing

Weigh out chemicals on pieces of paper and after transferring to the mixing vessel do not shake the paper but drop it into the sink and allow water to flow over it, thus dissolving the dust. Larger quantities are most conveniently weighed out in buckets.

### Measuring

For small quantities, a glass graduate marked off in ccs. or ounces should be used, for larger quantities use a bucket previously graduated, or mark off the inside of the tank or crock used for mixing. When measuring a liquid in a glass graduate place the eye on a level with the graduation mark and pour in the liquid until its lower surface coincides with this level. Owing to capillary attraction the liquid in contact with the walls of the graduate is drawn up the sides so that on viewing sideways it appears as if the liquid has two surfaces. All readings should be made from the lower surface and at room temperature because a warm liquid contracts on cooling.

### Dissolving

The rapidity with which a substance dissolves in any solvent depends on its solubility and degree of fineness, the temperature of the solvent, and the rate of stirring. Since a chemical is usually more soluble in hot water than in cold, the quickest way of mixing a solution is to powder it and dissolve in hot water by stirring. In the case of a few substances, like common salt, which are only slightly more soluble in hot than in cold water, the use of hot water is of no advantage.

Since most solutions are intended for use at ordinary temperatures, if hot water is used for dissolving, the solution must be cooled again if it is required for immediate use. Usually the time taken to do this is less than the extra time which would be taken up in dissolving the chemical in cold water. When mixing, therefore, as a general rule, dissolve the chemical in as small an amount of hot water as possible, cool off, and dilute with cold water.

After diluting with water, thoroughly shake the solution if in a bottle, or stir if in a tank, otherwise the water added will simply float on top of the heavier solution.

When mixing a solution in a tank, never add the dry chemicals to the tank but always make sure that the chemicals are dissolved by mixing in separate buckets and filtering into the tank.

If the water supply is not sufficiently cold, so that on diluting the hot solution the final liquid is not at the required temperature, the hot solution should be cooled by means of ice placed in a cloth bag to filter out the dirt.

In the case of anhydrous (dry) salts such as desiccated sodium carbonate, sodium sulphite, etc., always add the chemical to the water and not vice versa, otherwise a hard cake will form which will dissolve only with difficulty.

## Filtering

The purpose of filtering is to remove suspended matter such as dirt, caused by the presence of dust in the chemicals used, and also any residue or undissolved particles which might settle on the plates, film or paper during development. Here are several methods of removing such particles:

1. Allow the solution to stand and draw off or decant the clear supernatent liquid. This method is particularly useful when the suspended matter is so fine that it will pass through a coarse filter.

Since coarse particles settle quickly, the rate of settling of a semi-colloidal sludge can usually be hastened by mixing the solution in hot water, because the heat tends to coagulate the suspension and causes the particles to cluster together. Thus if crystals of sodium sulphide, which are brown due to the presence of iron, are dissolved in hot water the colloidal iron sulphide coagulates and settles out rapidly leaving a perfectly colorless solution.

2. Filter the solution through fabric or filter paper. Filtering through paper is usually a slow process and the continual dropping of the solution exposes it to the air thus causing oxidation. It is usually sufficient to filter through very fine cloth or muslin which has been washed thoroughly, otherwise the sizing matter in the fabric will be washed into the solution and settle out as a sludge.

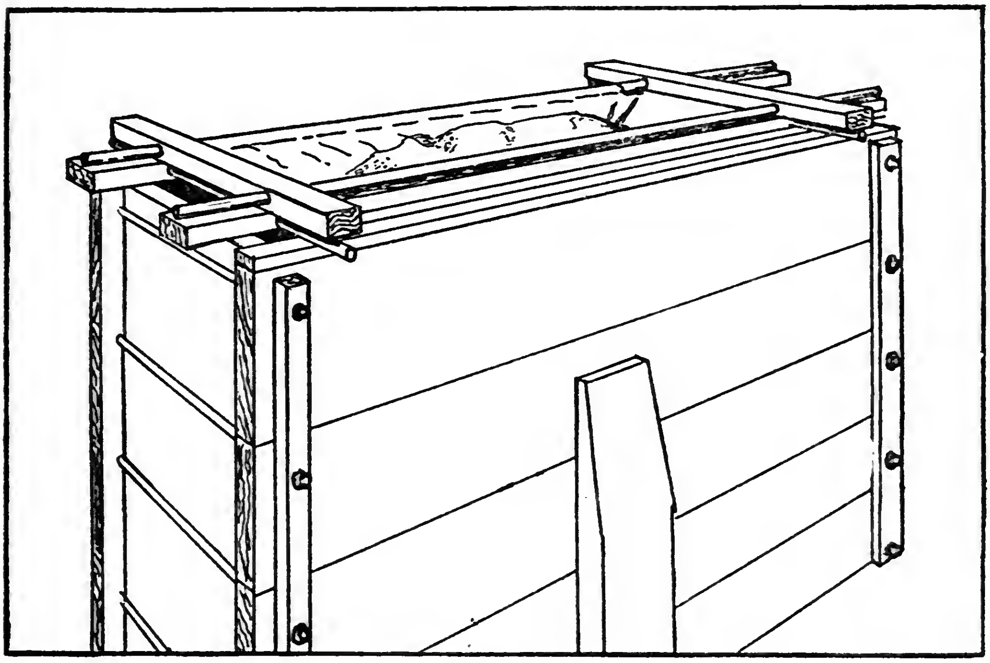


Fig. 32

3. As a modification of method 2, when mixing a quantity of solution in a tank, stretch a filter bag made of cloth over the tank, place the chemicals in the bag (about 6 inches deep) and allow hot water to flow into it. In this way the chemicals are dissolved and the solution filtered at the same time. A separate bag should be used for each solution so as to eliminate all risk of contamination.

The method of supporting the bag is shown in *Fig. 32* the bag being stretched over the wooden frame and held in place by means of four iron bars passing through loops along the edges of the bag. For mixing hypo, such a bag is indispensable.

In case of deep tanks such as are used for developing roll film and for motion picture work, the wooden frame can be dispensed with by adopting the arrangement shown in *Fig. 33*. The cloth bag about 6 inches deep is supported by means of iron bars passing through seams along opposite edges of the bag, and in turn the bars are held in place either by means of two pieces of wood passing over the ends of the bars, as shown, or by metal stirrups fitted to the sides of the tank.

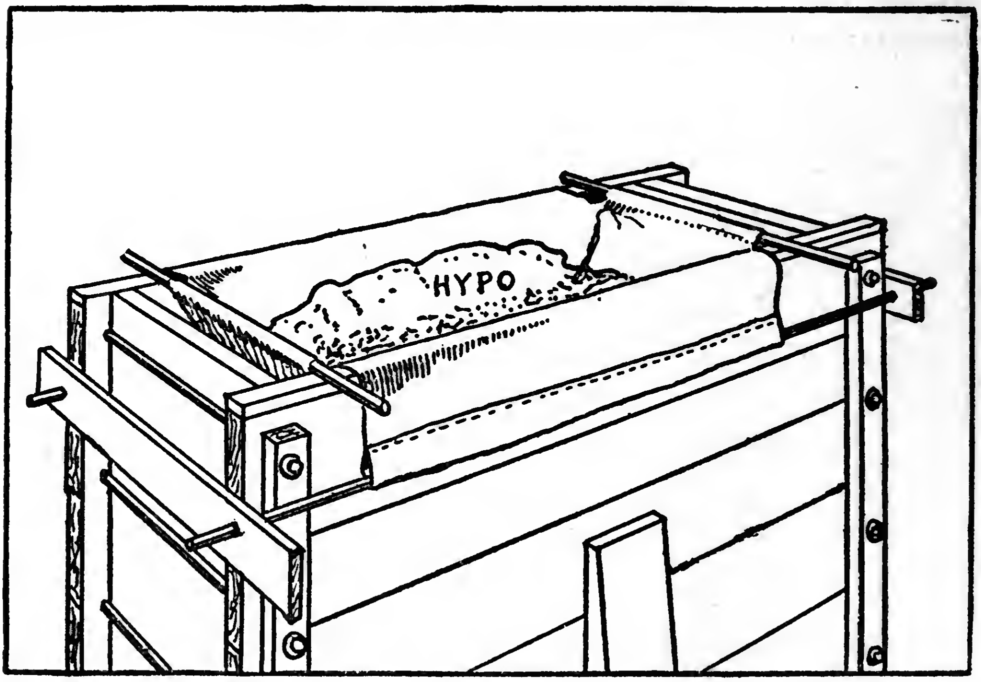



Fig. 33

It is important that the bag used should be shallow (6 to 9 inches deep), otherwise it will dip into the solution and the chemicals will dissolve very slowly.

4. A combination of methods 1 and 3 which follows is the best and most desirable:

(a) For quantities of solution up to 5 gallons, filter through cloth into a bottle or crock fitted with a side tube and pinch cock. In this way the fine particles settle out but the drainage tube is sufficiently high so as not to disturb the sediment. (*See Fig. 34.*)

(b) For motion picture work the best arrangement for mixing is to place the chemical room immediately above the developing


(*Courtesy of the Universal Film Company*)

NOTE PERFECTION OF DETAIL IN THIS RUSSIAN VILLAGE SET.

room and to mix the solutions in large wooden vats or enameled tanks connected with lead piping to the developing and fixing tanks in the dark room underneath. The solutions can then be mixed in advance, allowed to settle and be tested, so that only perfect solutions pass into the tanks located in the dark room.

### Removing Scum

When mixing a chemical solution, if method 4 above is not

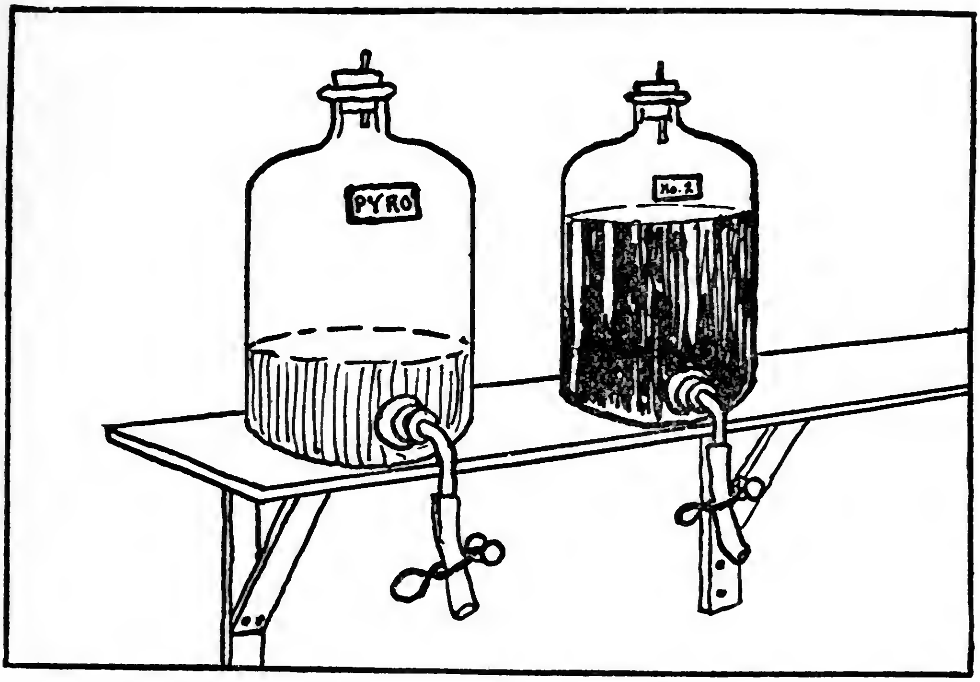



Fig. 34

adopted, and especially if the solutions are not filtered, a scum usually rises to the surface consisting of fibers, dust, etc., which should be skimmed off with a towel.

When a fixing bath has been used for some time and is allowed to stand undisturbed for a few days, any sulphuretted hydrogen gas which may be present in the atmosphere forms a metallic looking scum of silver sulphide at the surface of the liquid, and on immersing the film this scum attaches itself to the gelatine and prevents the action of the developer. Any such scum should be carefully removed, before use, with a sheet of blotting paper.

## Measuring Temperatures

Temperatures of solutions are measured either by the Centigrade or Fahrenheit thermometer. On the Centigrade scale water freezes at zero and boils at 100°, and on the Fahrenheit scale the corresponding readings are 32° and 212°, so that 100° C. are equivalent to 212°—32°=180° F. or 1° C. is equivalent to 9/5° F.

To convert degrees Centigrade to Fahrenheit, multiply by 9/5 and add 32. To convert degrees Fahrenheit to Centigrade subtract 32 and divide by 9/5.

In photography the Fahrenheit thermometer is almost universally employed. There would be no appreciable advantage adopting the Centigrade scale, since the precision of the Fahrenheit scale is greater. An error of 1° in reading the Centigrade scale means an error of practically 2° on the Fahrenheit scale.

## How to Mix Developing Solutions

A developer usually contains four solid ingredients as follows:

A. The developing agent (Elon, hydroquinone, pyro, paraminophenol, etc.).

B. The alkali (carbonates and hydroxides of lithium, sodium, potassium and ammonium).

C. The preservative (sulphites, bisulphites, and metabisulphites of sodium and potassium).

D. The restrainer (bromides and iodides of sodium, potassium and ammonium).

If a developing agent like hydroquinone is dissolved in water, the solution will either not develop at all or develop very slowly. On standing it will gradually turn brown due to what is known as oxidation or chemical combination of the hydroquinone with the oxygen present in the air in contact with the surface of the liquid. This oxidation product is of the nature of a dye and will stain fabrics or gelatine just like a dye solution.

On adding a solution of an alkali such as sodium carbonate, the hydroquinone at once becomes a developer. At the same time the rate of oxidation is increased to such an extent that the solution very rapidly turns dark brown, and if a plate is developed in this solution it becomes stained and fogged. The subject of "Chemical Fog" has been fully treated by the author in a separate article (Amer. Ann. Phot., 1919) to which the reader is referred.

If we add a little sodium bisulphite to the brown colored solution mentioned above, the brown color or stain is bleached out and a colorless solution is obtained. Therefore, if the preservative is first added to the developer, on adding the accelerator the solution remains perfectly clear because the sulphite preserves or protects the developing agent from oxidation by the air.

As a rule the preservative should be dissolved first.

An apparent exception to this rule should be made when dissolving Elon in concentrated solution. This developing substance is insoluble in a strong solution of sodium sulphite while if a sulphite solution is added to a strong solution of the developing agent a white precipitate is formed. When once the Elon is dissolved, however, it takes a fairly high concentration of sulphite to bring it out of solution again, though only a low concentration is required to prevent the Elon from dissolving.

On this account some direction sheets recommend that the Elon should be dissolved first, though if water containing dissolved air is used the Elon will oxidize and only a small amount of oxidation product is necessary to cause chemical fog. Therefore, when dissolving Elon, dissolve a portion of the sulphite sufficient to prevent immediate oxidation and yet not enough to prevent the Elon from dissolving readily. Then dissolve the Elon and finally add the remainder of the sulphite.

The alkali (say carbonate) may then be added:

(a) Dissolve the carbonate separately and add to the cooled Elon-sulphite solution. There is danger, however, of the Elon precipitating out before the carbonate is added.

(b) After dissolving a portion of the sulphite and adding the Elon, dissolve the remainder of the sulphite and carbonate together, cool and add to the Elon-sulphite mixture.

The above procedure is necessary so that when the carbonate is added the solutions are cool. If a hot carbonate solution is added to the developing agent, even in the presence of the preservative, a substance is formed which produces chemical fog.

In the case of developers containing no bromide, used for testing the quality of plates and for developing under-exposed negatives, it is absolutely necessary to mix the developer with cold water if a minimum of fog is desired.

In the case of some samples of paraminophenol which are discolored by the presence of oxidation products, these may be partially removed by boiling after adding to the sulphite solution. In this way the oxidation products are reduced by the sulphite to paraminophenol. The solution should be cooled again before adding the carbonate. If pure chemicals are used such a procedure is, of course, entirely unnecessary.

Bromides and iodides are added to a developer to compensate for any chemical fog produced by the developer, or inherent in the emulsion. It is immaterial at what stage during mixing the bromide is added.

When mixing a developer the following rules should therefore be followed:

1. Dissolve the preservative first. In the case of Elon dissolve only a portion of the sulphite first, dissolve the Elon, and then add the remainder of the sulphite.

2. Make sure that one chemical is dissolved before adding the next. If the alkali is added before the crystals of the developing agent are dissolved, each crystal becomes oxidized at the surface and the resulting solution will give fog.

3. Mix the developer at as low a temperature as possible.

4. In the case of desiccated chemicals like sodium carbonate and sodium sulphite, add the chemical to the water and not vice versa.

Two practical methods of mixing are possible, as follows:

(a) Dissolve all the chemicals in one bottle or vessel by adding the solid chemicals to the water in the correct order (in the formula the ingredients should be named in the order in which they are dissolved). For example, to mix the following formula proceed as follows:

| | |
|---|---|
| Sodium sulphite | 75 Gms. |
| Elon | 10 Gms. |
| Hydroquinone | 5 Gms. |
| Sodium Carbonate | 50 Gms. |
| Potassium Bromide | 1.5 Gms. |
| Water to | 1 L. |

Dissolve about ten grams of the sulphite in about 750 cc. of warm water and then dissolve the Elon. Now dissolve the remainder of the sulphite and then the hydroquinone. Finally add the carbonate and bromide and dilute to 1,000 cc.

(*Courtesy of Fox Film Corporation*)

SCOTT DUNLAP DIRECTING.

For large quantities the filter bag method should be used, the chemicals being placed in the bag and dissolved in the above order.

(b) An alternative method is to dissolve the preservative and developing agent in one vessel and the carbonate and bromide in another, cool and mix. This method is the safest and best for quantity production.

For example, to mix the following motion picture developer proceed as follows:

| | |
|---|---|
| Sodium Sulphite | 4 lbs. |
| Hydroquinone | 13 oz. |
| Sodium Carbonate | 4 lbs. |
| Potassium Bromide | 3 oz. |
| Water to | 10 gal. |

Dissolve the sulphite in about one gallon of hot water, then dissolve the hydroquinone and filter into the tank. Then add one gallon of cold water to the tank, dissolve the sodium carbonate and bromide in one gallon of hot water and filter this into the tank, immediately adding cold water up to ten gallons. The object of adding cold water to the tank is to cool off the solution before the carbonate is added.

## Mixing Concentrated Developers

The extent to which a developer may be concentrated is determined by the solubility of the least soluble constituent, because a stock solution should usually withstand cooling to 40° F. without any of the ingredients crystallizing out. Usually, the hydroquinone and Elon come ont of solution on cooling, but by adding alcohol (grain, wood, or denatured) up to a concentration of 10%, the crystallization is prevented, since the developing agents are very soluble in alcohol.

The addition of the alcohol does not prevent the other ingredients, such as sodium sulphite, from crystallizing out. In fact, the alcohol diminishes their solubility and therefore increases the tendency to come out of solution.

A paraminophenol-carbonate developer is difficult to prepare in concentrated form, though by adding a little caustic soda the solubility of the paraminophenol is increased and a stronger solution can be thus prepared.

When preparing concentrated developers it is important to observe carefully the rules of mixing. To obtain a colorless developer take care to keep the temperature of the solution as low as possible.

### Two-Solution Developers

A two-solution developer is simply a one-solution developer split into two parts, one containing the carbonate and bromide, the other containing the developing agent and preservatives so that the developer will oxidize less readily and therefore keep well. The reason it is customary to keep a developer like pyro in two solutions, is because pyro oxidizes much more readily than Elon or paraminophenol with a given amount of preservative.

For purposes of mixing, only one solution developers need be considered because the same rules regarding mixing apply in both cases.

### Developing Troubles

In order to explain the reason for any particular developer trouble it is necessary to understand thoroughly what takes place when the ingredients are mixed in the wrong order, or if any ingredient is omitted from the formula, also the effect of chemical impurities. It is impossible here to indicate every possible trouble but the more important ones may be listed as follows:

1. The developer gives fog or chemical fog. Fog is the chief trouble caused by faulty mixing. It may be due to any of the following reasons: Violation of the rules of mixing; mixing the solution too hot; omission of the bromide; addition of too much carbonate or too little sulphite; the use of impure chemicals; etc.

2. The solution is colored. As a general rule the developer when mixed should be colorless. If colored, the developer is liable to give fog. In the case of a pyro developer mixed with bisulphite which contains iron, the iron combines with the pyro to form an inky substance which imparts a dirty red color to the solution.

If a pyro developer is mixed as two separate solutions A and B, the pyro solution which usually contains only carbonate and bromide, should be perfectly colorless, though if carelessly mixed in dirty vessels it may be colored brown by the presence of a little pyro A.

3. If the solution does not develop, then either the developing agent or the carbonate was omitted during mixing.

## How to Mix Fixing Solutions

Fixing baths may be divided into the following classes:

1. Plain hypo solutions.

2. Acid hypo solutions consisting of hypo with the addition of sodium bisulphite, potassium metabisulphite, or sodium sulphite with acid.

3. Acid hardening hypo solutions.

1. Usually no difficulty is experienced when mixing a plain hypo solution. When mixing a quantity of solution in a tank the filter bag method should be used and the hypo dissolved in warm water because the temperature drops considerably while the hypo is dissolving. If a scum forms on the surface of the solution while standing, it should be removed by drawing the edge of a towel across the surface.

If a wooden cover is used for the tank, fungi often develop in a hypo solution and produce acid substances which tend to turn the solution milky. In such a case, the tank should be thoroughly cleaned and the cover faced with sheet lead.

A plain fixing bath, however, is seldom used because it gradually becomes alkaline from an accumulation of alkali carried over by the prints and plates from the developer. This tends to soften the gelatine, while the image continues to develop in the fixing bath. If two prints stick together, less development takes place at the point of contact causing uneven development. If the bath is acid, the acid kills or neutralizes the alkali in the developer carried over, thus preventing unevenness.

2. In order to mix an acid fixing bath intelligently it is necessary to understand a little about its chemistry.

Hypo can be made by boiling together sodium sulphite and flowers of sulphur until no more sulphur is dissolved. If acid is added to a hypo solution sulphur is again liberated, forming a milky solution known as milk of sulphur. If sodium sulphite is present, however, any sulphur which tends to come out of solution combines with the sulphite to form more hypo and the solution therefore remains clear.

This sulphur cannot be redissolved by adding sodium sulphite to the milky solution except by boiling. On standing it is apt to settle on prints or plates as a scum. All acid fixing baths therefore contain either sodium bisulphite, potassium metabisulphite, or a mixture of sodium sulphite and some acid, and the following directions for mixing should be followed:

(a) Do not add the bisulphite or acid sulphite solutions to the warm hypo solution. If the solutions are not perfectly cold when mixed the hypo will turn milky.

Experience has shown that potassium metabisulphite has less tendency to produce milkiness than sodium bisulphite, though for practical purposes the difference is almost negligible.

Of the common acids, sulphuric, hydrochloric, acetic, citric, etc., acetic, citric, and tartaric acids have less tendency to produce milkiness for a given degree of acidity than sulphuric, which fact would be expected from theoretical considerations.

(b) On keeping, an acid hypo solution gradually becomes milky, so that a stock solution of the sodium bisulphite, etc., should be kept and added to the plain hypo stock solution as required. For general purposes 50 cc. of a 50% sodium bisulphite solution are added to 1,000 cc. of a 35% hypo solution. If any considerable excess over this amount is added, the hypo rapidly turns milky owing to the liberation of sulphur, especially if the weather is warm.

3. Acid hardening baths are prepared by adding to hypo an acid hardening solution which contains the following ingredients:

(a) An acid such as acetic, citric, tartaric, lactic, sulphuric, etc., which stops development.

(b) A hardening agent such as alum, chrome alum or formalin.

(c) A preservative such as sodium sulphite or sodium bisulphite.

The latter acts as a preservative in two ways: It prevents the formation of sulphur by the action of the acid on the hypo, and, also prevents the developer carried over into the fixing bath from oxidizing and turning brown.

### How to Mix the Acid Hardener

Prepare the acid hardening solution as a separate stock solution and add this to the hypo solution as required.

The order of mixing is important.

(a) When mixing in one vessel, first dissolve the alum in warm water, then add the acid and add the sulphite immediately; otherwise, if the acid alum solution is allowed to stand, the alum will crystalize out again. It is sometimes recommended to reverse the process, namely, dissolve the sulphite first, add the acid, and then the alum, but unless the alum is finely powdered it does not readily dissolve unless the solution is warm. In this case sulphur dioxide gas is given off from the acid sulphite solution.

(b) The best method is to dissolve the alum and sulphite in separate solutions, cool, add the acid to the sulphite and then add the alum solution.

If the order of mixing is reversed and the alum first added to the sulphite, a white sludge of aluminum sulphite is formed which dissolves with difficulty when the acid is added. If after mixing the hardener is milky and a sludge settles out, there is a relative insufficiency of acid. That is the acid used was not up to strength, or too much alum or sulphite was added.

With all other hardening baths the order of mixing is the same.

## Fixing Bath Troubles

1. Milkiness of the fixing bath.

Sometimes a fixing bath turns milky immediately on adding the hardener and sometimes after being in use for some time. The milkiness may be of two kinds:

A. If the precipitate settles very slowly on standing, the milkiness is due to sulphur caused by the following conditions:

(a) Too much acid in the hardener.

(b) Too little sulphite or the use of impure sulphite (in which case there is not sufficient present to protect the hypo from the acid).

(c) High temperature. The hardener should only be added to the hypo solution when at room temperature. If the temperature of the acid fixing bath is over 85° F. it will not remain clear longer than a few days even when mixed correctly. The only remedy is to throw the bath away and mix fresh solution as required.

B. If the milkiness disappears on standing for a few hours, and a gelatinous sludge of aluminum sulphite settles out, this is caused by:

(a) Too little acid in the hardener. For example, supposing a formula calls for pure glacial (98%) acetic acid and 28% acid is used by mistake, then we have added less than one-third the required amount.

(b) Too little hardener in the fixing bath. When fixing prints, a relatively large proportion of the developer is carried over to the fixing bath. This soon neutralizes the acid and permits the formation of aluminum sulphite. A fixing bath with the correct proportion of hardener, when exhausted, still contains alum and sulphite but no acid, and these combine to form a sludge of aluminum sulphite.

It is extremely important therefore to use only acid of known strength. Avoid trouble by using neither more nor less acid than is called for in the formula.

2. The bath does not harden.

A frequent cause of insufficient hardening is the use of inferior alum which does not contain the correct proportion of aluminum sulphate. An exhausted bath which is alkaline will also harden very slowly. Alum hardens best in acid solution.

### Miscellaneous Solutions

The number of miscellaneous solutions used in photography for intensifying, reducing, toning, etc., is so large that it is beyond the scope of this book to deal with individual cases. The method of procedure is much the same as when mixing developers, and the order of mixing is usually stated specifically.

### Substitution of Chemicals

Occasion arises often when the photographer is out of stock of some particular chemical and he is tempted to substitute one chemical for another. In this chapter it will be shown how far substitution is possible in the case of developing and fixing baths. These remarks usually apply to solutions in general.

### Substitutes for Potassium Salts

In view of the present scarcity of potassium salts and their greater expense as compared with sodium salts, the question arises as to what extent they can be replaced by salts of sodium or ammonium.

As a general rule, for photographic purposes, a potassium salt can be replaced by a sodium salt weight for weight, the error caused by the difference in molecular weight of the two salts being usually negligible. There are many exceptions, however, where there is a difference in physical properties of the two salts for example, potassium carbonate and sodium bichromate are deliquescent (*i.e.*, they attract the moisture present in the atmosphere) while sodium carbonate and potassium bichromate are not.

### Substition in Developing Formulae

1. The developing Agent.

As a general rule it is not possible to replace one developing agent by another and obtain a developer with identical properties, since each developing agent has its own characteristics as regards rate of development, fog, color of image produced, etc. In some cases, however, a close approximation can be made. For example substitute Elon by Kodelon (or paramidophenol) providing the developer is sufficiently dilute to permit of sufficient paramidophenol being dissolved. This applies either to an all Elon or an Elon-hydroquinone formula.

If in an Elon-hydroquinone (or E-H) formula paramidophenol is substituted for the Elon and the activity of the developer is increased by the addition of alkali, the effect of the alkali is proportionately greater on the hydroquinone than on the paramidophenol so that a rapid hard working developer is obtained. To avoid this, proportionally more paramidophenol is required than if Elon is used.

2. The preservative.

It is not customary to substitute sodium bisulphite for potassium metabisulphite weight by weight, though in a plain fixing bath, sodium bisulphite has a slightly greater tendency to produce sulphurization than the potassium salt.

The question is often asked as to the difference in action between sodium sulphite and sodium bisulphite. Sodium bisulphite may be considered as a compound of sodium sulphite and sulphurous acid, and therefore reacts acid. Sodium sulphite is alkaline. In the case of a two-solution pyro formula where the pyro A solution is preserved with oxalic acid or sodium bisulphite, an equal weight of sodium sulphite would not preserve as well, since pyro oxidizes much more readily in alkaline than in acid solution.

In the case of a one-solution developer containing, say, sodium sulphite, sodium bisulphite and sodium carbonate, the bisulphite is converted to sulphite by the sodium carbonate according to the following equation:

Sodium Bisulphite + Sodium Carbonate = Sodium Sulphite + Sodium Bicarbonate.

So that a corresponding amount of sodium sulphite might just as well have been added in the first place. Sodium bisulphite neutralizes or destroys an equivalent amount of sodium carbonate thus reducing the proportion of alkali and therefore exerting an apparent restraining action. The developer apparently keeps longer because some of the carbonate has been destroyed.

The relative amounts of different salts which produce the same preserving action is given in the following table:

| | |
|---|---|
| Sodium sulphite .................... | 1.0 part |
| Sodium bisulphite .................... | 0.83 part |
| Potassium metabisulphite ............ | 0.88 part |

For a two-solution developer therefore use sodium bisulphite. In the case of a single solution developer, containing alkali, use sodium sulphite, because in this case no advantage is gained by using a mixture of sulphite and bisulphite.

3. The Alkali.

The common alkalis are the carbonates and hydroxides of sodium, potassium or ammonium. Substances like acetone, tribasic sodium phosphate, borax, and amines are occasionally used but will not be considered here.

When sodium carbonate is dissolved in water a small proportion of it reacts with the water forming caustic soda and sodium bicarbonate. This process is called hydrolysis though only a small portion of the carbonate is hydrolyzed at any moment. As the caustic soda formed is used up in development, more carbonate hydrolyzes so we can consider that carbonate acts as a reservoir of caustic alkali. If, in the first place, a solution of caustic soda was used of the same alkalinity as the carbonate it would soon be used up. The use of carbonate therefore enables us to use a small concentration of alkali and yet keep it constant during development.

It is rarely possible therefore to replace caustic alkalis by carbonated alkalis such as sodium or potassium carbonate.

Potassium carbonate is slightly more active than sodium carbonate in solution because it hydrolyzes to a greater extent. For

*(Courtesy of the Universal Film Company)*

A HAZARDOUS POSITION.

developing motion picture film on a reel when the developer may splash on the floor, potassium carbonate cannot be substituted by sodium carbonate. Because of the deliquescent nature of potassium carbonate, the splashes of solution remain moist thus preventing the formation of carbonate dust in the air.

Caustic soda and caustic potash may be replaced weight for weight in most formulae.

Ammonia and ammonium carbonate are seldom used in developers on account of their odor and the fact that they tend to cause dichroic fog.

### Desiccated and Crystal Sodas

Sodium carbonate and sodium sulphite are often supplied in two forms: Crystals and desiccated or dry, which is sometimes called anhydrous because it does not contain water of crystalization.

Desiccated sodas possess the advantage that they occupy less than half the bulk of the crystals, while desiccated sodium sulphite is much less liable to oxidation by the air than the crystalline variety.

The sodas should be substituted as follows:

One part by weight of sodium carbonate (desiccated) for three parts by weight of the crystals.

One part by weight of sodium sulphite (desiccated) for two parts by weight of the crystals.

4. The Restrainer.

Potassium bromide may be substituted by an equal weight of sodium bromide. Ammonium bromide should not be used in a developer because the alkali liberates ammonia gas and this too tends to produce dichroic fog.

### Substitution in the Fixing Bath

Sulphites and Bisulphites.

The same remarks apply as to preservatives in the developer.

Alums.

An alum is a compound or double salt of aluminum sulphate or chromium sulphate with either sodium, potassium or ammonium sulphate. The hardening action is produced only by the aluminum or chromium sulphate, so that equivalent weights of aluminum sulphate and of sodium, potassium, or ammonium alum should exert the same hardening action.

The following conclusions are the result of a series of practical tests made by the author.

(a) Equivalent amounts of potash alum and aluminum sulphate exert the same hardening action, two parts by weight of aluminum sulphate, being equivalent to three parts by weight of potash alum. Commercially pure aluminum sulphate is satisfactory if this does not contain an excess of iron. If the sample is acid, the solution should be neutralized with ammonia. When mixing the usual liquid hardener formula with commercial aluminum sulphate, a slight milky suspension is formed which should be allowed to settle and be filtered off.

(b) There is no appreciable difference between sodium, potassium and ammonium alum in their hardening action when substituted weight for weight in the usual formulae. In practice, if any difference in hardening action occurs, it is due to the use of impure alums. If the impurities are harmless, an increased amount of the alum should be used so that the content of aluminum sulphate is the same as that in the potash alum called for by the particular formula.

When using ammonium alum, if the fixing bath becomes alkaline by virtue of a neutralization of the acid by the developer carried over, ammonia will be liberated causing dichroic fog and stain. No trouble will be experienced, however, if care is taken to keep the bath acid.

Pure chrome alum may also be substituted for potash alum, as above, though it has a slightly greater tendency to precipitate sulphur than potash alum. It has this advantage, however. It does not form a basic sulphite as rapidly as potash alum, so that a chrome alum fixing bath remains clear even when appreciably alkaline.

Acids.

The most commonly used acids are acetic, citric, tartaric, and sometimes lactic. Strong acids like sulphuric are seldom used because of the great tendency to liberate sulphur. Weaker acids, like the above, bear the same relation to a strong acid as a carbonated alkali to a caustic alkali, that is they act as a reservoir of acid. Thus only a small proportion of the acid is available for reaction in solution at any one time.

Acetic acid is usually supplied in two strengths, glacial (98%) and 28% acid. One volume of glacial acid is equivalent to three and a half volumes of 28% acid.

Citric and tartaric may be substituted weight for weight. When used in place of acetic, substitute in the ratio of one gram of citric for every 3 ccs. of 28% acetic acid.

These acids are not quite as satisfactory as acetic because, for a given degree of acidity as measured by the amount of alkaline developer which can be added to the fixing bath before the bath becomes neutral, citric and tartaric acids have a greater tendency to precipitate sulphur from the hypo than acetic acid.

## Purity of Chemicals

### *The Water Supply*

Water is the most important chemical used in photography. It is most important to know to what extent the impurities present may be harmful to the various operations and how these impurities may be removed.

Excluding distilled water, rain water, and water from melted ice or snow, the following impurities may be present:

1. Dissolved salts such as bicarbonates, chlorides, and sulphates of calcium, magnesium, sodium and potassium. In case calcium salts are present and a developing formula is used containing sodium bisulphite or potassium metabisulphite, fine needle-shaped crystals of calcium sulphite are apt to separate out as a sludge in the developer on standing. The sludge is harmless if allowed to settle, though the developer is robbed of the amount of sulphite required to form the sludge. If the developer is agitated, the sludge will cause trouble by settling out on the emulsions of plates, films, etc. Other salts have usually little effect on a developer although chlorides and bromides exert a restraining action.

Dissolved salts often cause trouble by crystallizing on the film after drying. Although not always visible as crystals to the eye, they detract from the transparency of the film.

2. Suspended matter in the form of dirt and iron rust, if not filtered or allowed to settle will cause spots.

3. Slime, consisting of animal or vegetable colloidal matter and which is not removed by filtering. If slimy water is used for mixing solutions, the colloidal matter gradually coagulates and settles out in the solution as a sludge.

4. Dissolved gases such as air, sulphuretted hydrogen, etc.

Water dissolves about 2% of air at 70° F. When a developing agent, like hydroquinone, is dissolved without the addition of sulphite, the oxygen present in the water combines with the developing agent forming an oxide which will cause chemical fog.

Sulphuretted hydrogen gas present in sulphur water will also cause bad chemical fog. The gas may be removed by boiling or by precipitation with lead acetate.

### Purification of Water

Water may be purified as follows:

1. By distillation: Distilled water should be used whenever possible for mixing solutions.

2. By boiling: This coagulates the colloidal matter and changes certain lime salts to the insoluble condition which then settles out. Dissolved gases such as air, sulphuretted hydrogen, etc., are removed. Therefore, unless the water contains an excessive amount of dissolved salts, it is usually sufficient to boil it and allow it to settle.

3. By chemical treatment: If large quantities of water are required, chemical methods of purification must be employed, though it is only possible to remove lime salts, slime and colloidal matter in this way.

Excessive amounts of dissolved lime salts are very objectionable. After washing, if drops of water remain on the plates or film, when the water evaporates, the dissolved salts in the water become visible as a white scum.

The following methods of chemical purification may be adopted:

(a) Add alum to the water in the proportion of one gram to four liters. This coagulates the slime which carries down any suspended particles, and the solution rapidly clears. This method does not remove dissolved salts, while the small amount of alum introduced into the water has no harmful effect on the developer.

(b) Add a solution of sodium oxalate until no further precipitate forms. This method removes the calcium and magnesium salts and coagulates the slime, though sodium and potassium salts are left in solution.

(c) Most of the commercial methods of water softening may be employed though such methods do not remove sodium and potassium salts.

*(Courtesy of Douglas Fairbanks Film Company)*

DOUGLAS FAIRBANKS AND CHARLEY CHAPLIN BURLESQUING THE FILM DIRECTOR WHO INVARIABLY LINES UP HIS "MOVIE SHOTS" IN THIS FASHION.

The "Decalso" process of water softening is one which can be recommended. The water is passed through a tank containing sodium aluminum silicate which is a Zeolite, and possesses the power of exchanging its sodium for the calcium and magnesium present in the water. When the Zeolite thus loaded with calcium and magnesium is washed in a strong solution of common salt (sodium chloride) it exchanges the calcium and magnesium again for sodium and is thus regenerated, and in condition for further softening. Full particulars may be obtained from the American Water Softening Company, 1011 Chestnut Street, Philadelphia, Pa.

## Impurities in Developing and Fixing Chemicals

It is beyond our scope to indicate all the possible impurities which may be present in photographic chemicals. For a more detailed account the reader is referred to the paper by H. T. Clarke on "The Examination of Organic Developing Agents" (Phot. J. Amer., Nov., 1918, p. 481), which contains a number of analysis of developers recently placed on the market under fancy names and containing such substances as starch, sugar, salt, borax, etc.

We are concerned only with the impurities which are not intentionally added as adulterants, usually present in chemicals.

Impurities may have access to photographic chemicals in three ways: (a) during manufacture, (b) during storage, (c) during mixing and storage of the solution.

(a) If chemicals of repute are purchased, the photographer need not worry about impurities.

If the Elon, hydroquinone or pyro is colored, the presence of fogging agent should be suspected, although some colored samples do not give any more fog than colorless ones.

Many metallic compounds such as salts of copper and tin, metallic sulphides, etc., exert a powerful fogging action even when present only in minute quantities and should be avoided. The following table indicates the nature and effect of the more common impurities present in the chemicals used for developing and fixing baths:

| *Chemical* | *Chief Impurity* | *Effect of Impurities* |
|---|---|---|
| Pyro, hydroquinone, etc. | Oxidation products and adulterants | Chemical fog<br>Adulterants weaken the effect of the developer |
| Sodium sulphite | Sodium sulphate | Keeping properties of the developer are impaired |
| Sodium bisulphite | Iron and sodium sulphate | Iron gives a dirty red solution with pyro |
| Caustic soda | Sodium carbonate | Decreases the accelerating power |
| Hypo | Sodium sulphite | Diminishes the fixing power |
| Alum | Sodium sulphate and ammonium sulphate | Diminishes the hardening action |
| Chrome alum | Ammonium sulphate and sulphuric acid | Excess of acid tends to cause sulphurization of the fixing bath |
| Acetic acid | Water | Deficiency of acid causes milkiness of the acid fixing bath due to the precipitation of aluminum sulphite |

(b) For impurities introduced during storage see "Storage of Chemicals."

(c) If during mixing the water contains dissolved air and the developing agent is dissolved before the sulphite, it becomes oxidized and the oxidation product formed causes fog. (See "Mixing of Developers," "Storage of Solutions" and article on "Chemical Fog.")

### Storage of Chemicals

Chemicals should be stored in well corked or well stoppered jars in a cool, dry place. Most chemicals are affected by air which contains oxygen, carbon dioxide gas, and moisture.

(a) Oxygen readily attacks such substances as sodium sulphite, especially in the presence of moisture, converting it into sodium sulphate, which is useless as a preservative. With crystallized sodium sulphite, the sodium sulphate forms on the outside of the crystals as a powder; this may be washed off and the crystals dried. It is necessary to make chemical tests to detect sodium sulphate in desiccated sulphite.

Other substances which combine with oxygen, and are therefore said to be "oxidized," are sodium bisulphite and potassium metabisulphite and all developing agents such as pyro, hydroquinone, etc., which turn more or less brown, the extent of the color roughly indicating the degree of oxidation.

(b) Carbon dioxide gas combines with substances like caustic soda and caustic potash converting them into the corresponding carbonated alkalis which are less reactive. If caustic soda is kept in a stoppered bottle the stopper usually becomes cemented fast by the sodium carbonate formed, so that it should be kept in a waxed corked bottle. Owing to the solvent action of the caustic alkalis on glass the inside of the glass bottle containing caustic or strongly carbonated solutions becomes frosted, though the amount of glass thus dissolved away will usually do no harm.

(c) Certain chemicals have a strong attraction or affinity for the moisture present in the atmosphere and gradually dissolve forming a solution in the water thus absorbed. This phenomenon is termed "deliquescence" and the chemicals are said to "deliquesce." Familiar examples are ammonium thiocyanate, potassium carbonate, caustic soda, caustic potash, sodium sulphide, uranium nitrate, sodium bichromate, etc., which should be stored in corked bottles and the neck should be dipped in melted paraffin wax.

As mentioned above, it is difficult to prepare a solution of definite percentage strength from a chemical which has deliquesced, though it is usually sufficient to drain off the crystals, or to use a hydrometer, referring to a table giving the hydrometer readings in terms of percentage strength.

(d) While some chemicals absorb moisture as above, others give up their water of crystallization to the atmosphere and therefore lose their crystalline form and fall to a powder and are then said to have "efflorescence," the phenomenon being termed "efflorenscence." Some crystals do not contain water and therefore cannot effloresce.

A very dry atmosphere is suitable therefore for storing deliquescent salts but not for efflorescent salts. The only way to store chemicals is to isolate them from the air by suitably sealing.

## How to Store Solutions

Stock solutions and developers should be stored either in large bottles, earthenware crocks, wooden vats, or in tanks of resistive material so arranged that the liquid may be drawn off at the side and near the bottom.

Large glass bottles and crocks should be fitted with a right-angled glass or lead tube passing through a rubber stopper wired to the bottle, the tube being opened and closed by means of a pinch cock clamping a short length of rubber tubing.

In case a solution such as pyro has to be stored for a long time and withdrawn at intervals, an absorption bottle containing alkaline pyro may be fitted at the intake, which absorbs oxygen from the air as it enters the bottle after withdrawing part of the solution.

It is often recommended to pour a layer of refined material oil on the surface of a solution to protect it from the air, though this is very messy when the bottle has to be refilled.

A battery of stock solution bottles is shown in *Fig. 34* the bottles being arranged on lead covered shelves under which a large trough is placed, or, the floor may be so arranged as to form a sink so that in case of accidental breakage no serious damage is done. This precaution is of special importance in the case of hypo solutions which might otherwise flood an entire building and inoculate the various rooms with hypo dust causing an epidemic of spots.

*(Courtesy of the Goldwyn Film Company)*

BUILDING A MINIATURE FOR "THAIS."

## Chapter IX

# DEVELOPMENT OF THE NEGATIVE

AFTER the picture has been taken, the cameraman delivers the film to the negative developing department, where it is developed and fixed in a manner very similar to that adopted in developing still pictures. Before proceeding with the development of the entire film, when the exposure and light conditions are unknown, a short piece is cut off and developed independently, so that the proper treatment may be determined without endangering the entire reel.

The exposed film is wrapped spirally around a light rectangular frame or rack, for convenience in handling, and is then dipped into a tank containing the developing solution. This arrangement enables the operator to agitate the film in the solution and examine it without danger of injury to the delicate sensitized surface. After the negative has been developed to the required density it is placed in the fixing bath of sodium hyposulphite where it remains until all the remaining active silver salts in the emulsion are dissolved out leaving an image of reduced metallic silver which can no longer be affected by the light.

Fixing having been completed, the film is thoroughly washed in clean water to remove the last traces of hypo. The film is next dried upon large revolving wooden drums, usually driven by power. The motion of the drums throws off any small drops of water that may adhere to the back of the film and keeps a constant stream of warm air moving over the emulsion side.

In some laboratories before drying, the film is given a final treatment in dilute solution of glycerine and water. A small percentage of the glycerine remains with the film even after it has dried and owing to the moisture absorbing properties of the glycerine enough moisture is retained to keep the film in a soft and pliable condition. When the glycerine has been lost after a considerable service, by evaporation or other cause, the film becomes brittle and must be given another treatment in the glycerine bath. This is a precaution that is not needed so much today as modern film is much more pliable than that used a few years ago when the glycerine bath was a necessity.

Before the introduction of tank development the drum system was used but is now practically discarded. For convenience in developing long films they were often wound around large drums similar to the drying drums. After the film was wound on the drum it was suspended over the developing tank in such a way that the lower edge of the drum and the film dipped into the solution. The drum was then revolved until the negative was developed to the proper density, and then was transferred to the fixing and washing baths.

Machine development is to some extent now superseding the tank method. In machine development the film is led by means of sprockets and pulleys successively through the developer, the short-stop, the wash water, and into a drying chamber and it comes out finished and dried upon a take-up spindle. By this method all the different steps in development are proceeding at once upon different portions of the same roll of film. The Pathé and Gaumont companies in this country and Europe, and some companies in England, have successfully used machine development for a number of years. Several companies finishing or "processing" motion picture film by machine development are now in operation in the United States.

The beginner, when he handles for the first time a coil of sensitized film measuring 1⅜ inches in width and perhaps 200 feet in length, might hesitate to attempt its development. He might prefer to dispatch it to a firm prepared to carry out this work for a light charge, confident that with the facilities at their command, and with their accumulated experience, they would be able to bring out his work to the best advantage.

As a matter of fact it is by no means so difficult as it appears at first and the rudiments of the process may be grasped readily by a person of average intelligence. Success, as in other handicrafts, can be achieved only with practice.

Cinematography, being a peculiar and special branch of the photographic art, demanding the use of new and unfamiliar tools has been responsible for the perfection of particular devices and methods to assist and facilitate development. In the early days the worker had to worry through the task and was compelled to undertake many doubtful experiments. Today the beginner is able to profit from the mistakes of the pioneers and has at his disposal all the appliances and processes which have proved their worth. After one or two trials the worker will realize that the development of a 200-foot length of celluloid ribbon is no more difficult than the development of an ordinary kodak spool.

One thing the beginner will do well to bear in mind. He should adopt some particular brand of film and cling to it after he has become acquainted with its emulsion, speed, composition and peculiar characteristics. There are three or four different makes upon the market but it is preferable to select a film which is easily obtainable at any time and in any part of the world. It is strongly urged that the beginner select the Eastman stock for this if for no other reason. The Eastman organization has its tentacles spread throughout the world. It has thousands of agencies in immediate touch with the different national companies. The result is that this film can be purchased without difficulty in nearly all parts of the globe. If a local dealer does not stock it, he can procure it to order within a day or two. Moreover the film will be new and in perfect condition.

There are many other reasons why it is advisable to select and to adhere to this stock, which although of a technical character are of much importance to the user. It must be borne in mind that the technique and chemistry of cinematography are still in their infancy and the technical staff retained for the preparation of the various ingredients employed in the sensitizing of the film are striving constantly to improve and to increase the speed or sensitiveness of the emulsion. The result is that the worker who uses Eastman film keeps pace with developments. The makers of this ribbon were the first to discover a base and emulsion suited to moving picture work. This was achieved only after the erpesditure of enormous sums of money, after hundreds of fruitless experiments and with the co-operation of the highest technical and chemical skill. Under these circumstances the limitations of the base and of the emulsion became thoroughly understood, so that the film is certain to maintain the highest quality. On the other hand, those firms who have embarked upon the manufacture of this commodity only within recent years, have still to face and to overcome many pitfalls which the older concern discovered and surmounted years ago. So the film marketed by younger organizations is apt to vary in quality.

Before the beginner attempts development he must make sure that his dark room and accessories are adequate. To seek success with makeshifts in the first instance is to court failure. Many of the utensils employed in the dark room can be fashioned by any handy man. They may lack finish but so long as they perform their work properly, nothing more is necessary.

The following small outfit which has a capacity of little more than 50 feet of film will go into a space about 32 by 32 inches by 8 inches thick, including a dozen racks. *Figure 35* shows the construction of the arms of the rack which are made of some hard close-grained wood like maple, the pins are made of what is called dowel-pin stock, small rods of hardwood used by cabinetmakers to pin the edges of boards together in fine cabinet work.

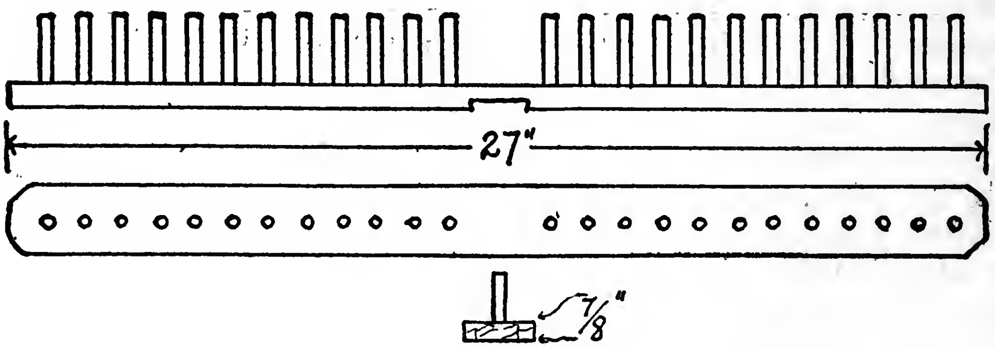
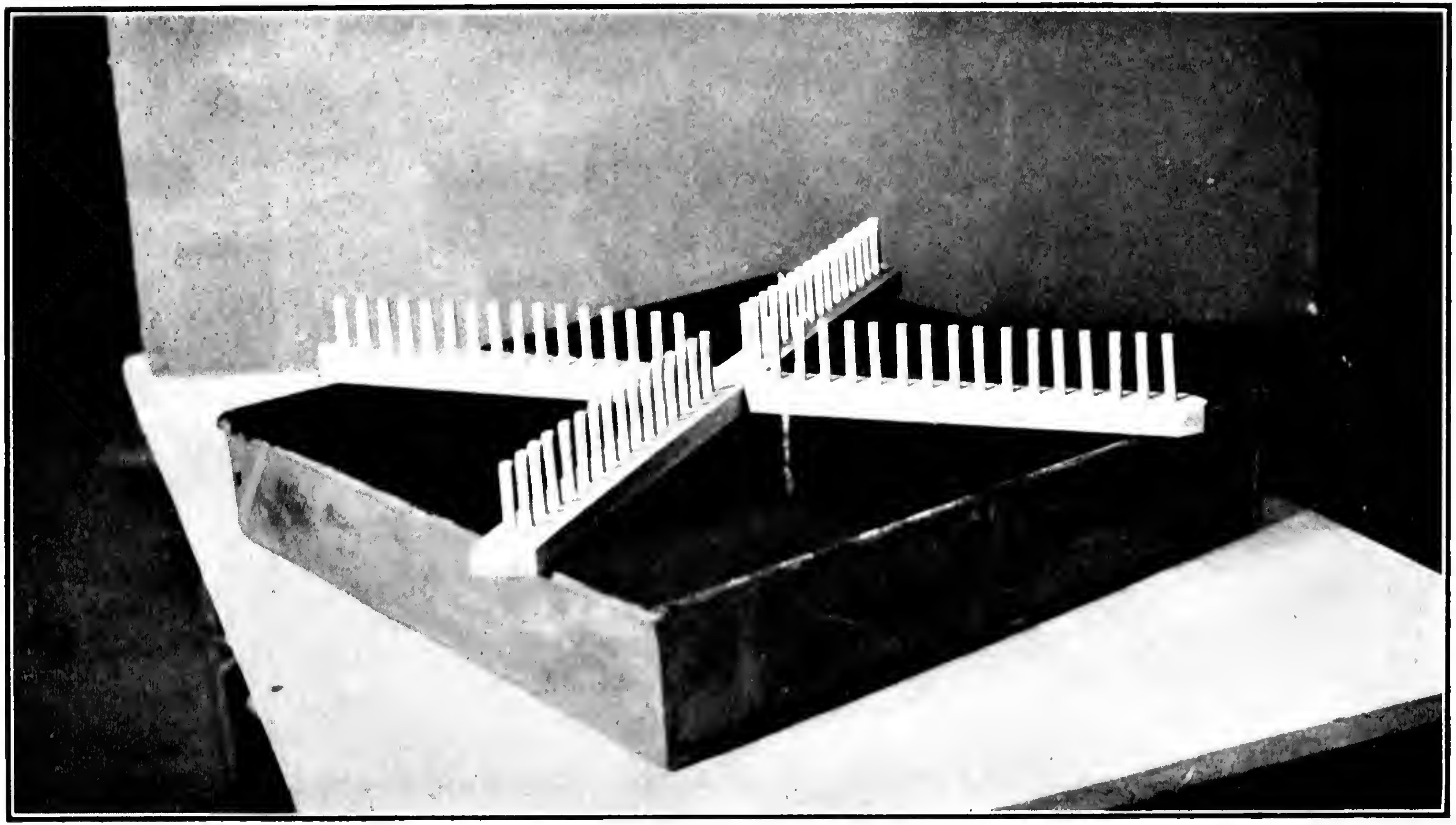



Fig. 35

They may be obtained from almost any lumber yard or mill. The ones used in the rack described were 3/16 inch in diameter and protrude two inches from the rack arm. Two rack arms crossed make a rack on which a little more than 50 feet of film may be wound spirally, beginning at the center. They are fastened together with two screws so that they may be readily taken apart for greater convenience in transporting.

By a little calculation, if one wished a rack of larger capacity, a 75 or 100-foot rack may be constructed in the same manner. A rack of 100 feet capacity is about the limit of this form of developing apparatus, as anything larger becomes too cumbersome and the swelling action of the developer causes the film to loosen and gives trouble, as the film seems bound to stick together. Still racks of larger capacity have been made with four cross arms instead of two. This only reduces the trouble to a slight extent, so that it is not advisable even in the hundred-foot racks, unless the film is stretched very tightly, for one is apt to exper-



TRAY AND RACK

ience trouble from slack strands adhering and stopping the action of the developer where they stick together.

If the maker is an amateur metal worker, he may make an apparatus quite a bit more compact by constructing it of square brass rod stock, with smaller brass pins, which on account of their size may be set closer together than the wooden dowels.

A developing tray 21 inches square inside measurement and 4 inches deep will accommodate the diagonal cross arms of the 27-inch rack. The trays may be made of wood, but by getting a sheet metal worker to construct the trays of sheet iron, a

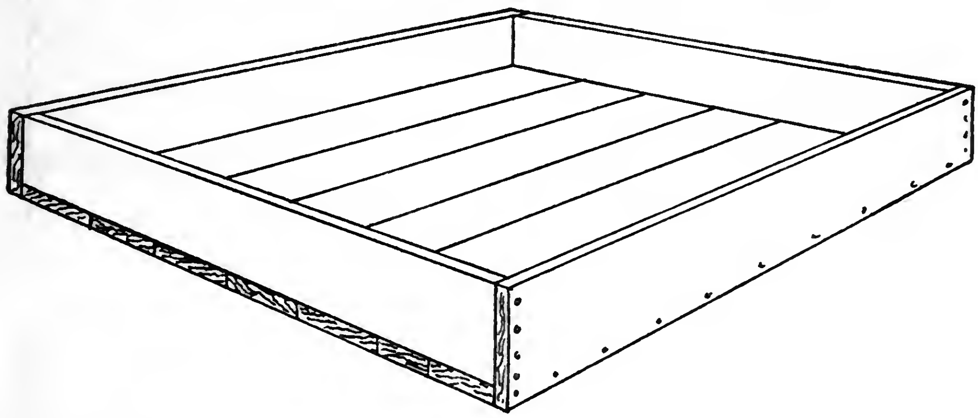


Fig. 36

much lighter and more compact nest of trays may be made. A set of three trays is necessary, one for the developer, one for the Hypo and one for a washing tray. Each of these in succession is just enough larger than the one preceding so that they will nest together for packing.

For those who wish to construct their own trays of wood *Figure 36* shows a wooden developing tray which may be constructed of any sort of wood which may be at hand. It is not advisable to try to make this tray water-tight since the action of the water and developing fluids will inevitably warp it so that it would leak too badly to use. Wooden trays are easily rendered water-proof by lining with rubber cloth or in the case of hypo and washing trays, with ordinary table oil cloth. Oil cloth cannot be used in a developing tray unless it is covered with a good coat of Probus paint, as the alkali in the developer dissolves the water-proof coating on the oil cloth.

*Figure 37* shows a square of rubber cloth cut for lining the developing tray. Use surgeon's white rubber sheeting, which may be obtained from any drug store. This rubber cloth is impervious to the action of the developer and by turning the folded corner

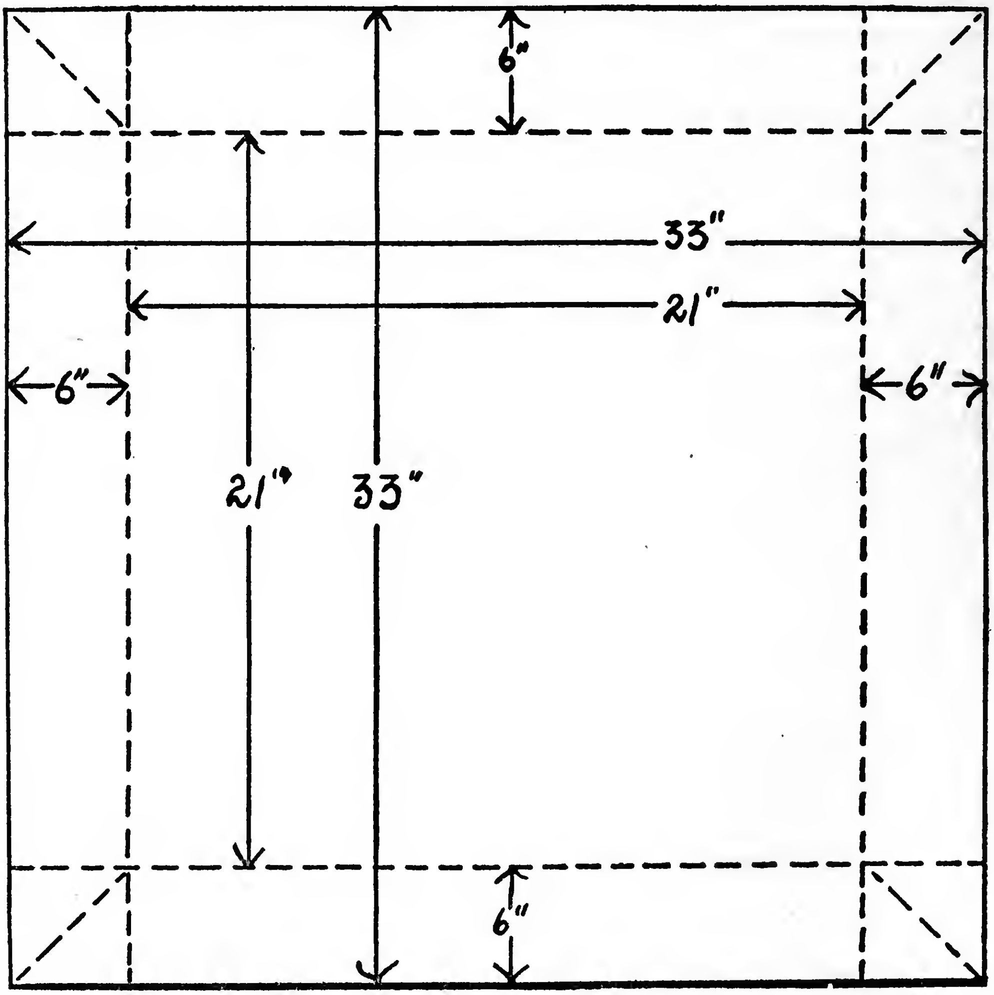



Fig. 37

as shown in *Figure 38,* a smooth water-proof joint can easily be made. Place the cloth inside the tray with the rubber surface up, spread it smoothly inside and turn the edges over the edge of the tray, a two-inch overlap being provided for in the diagram. Fasten lightly with tacks until the cloth is smoothly arranged, cutting down the corners just far enough to meet the top of the tray and then fasten permanently by tacking half-round beading along the top edge of the tray, after which the small amount of cloth protruding may be trimmed off, leaving a neat cloth-lined tray which is water- and solution-proof. The cut shows a rack on an empty tray ready for winding on the film.

Metal trays should be painted thoroughly inside with a coating of Probus paint, which is a paint impervious to the action of either acids or alkalies and which may be obtained from any dealer in photographic supplies. Sheet-iron is better than galvanized iron or tin as the coating of tin or zinc is liable to peel off after short use and expose the metal underneath to the action of the solutions.

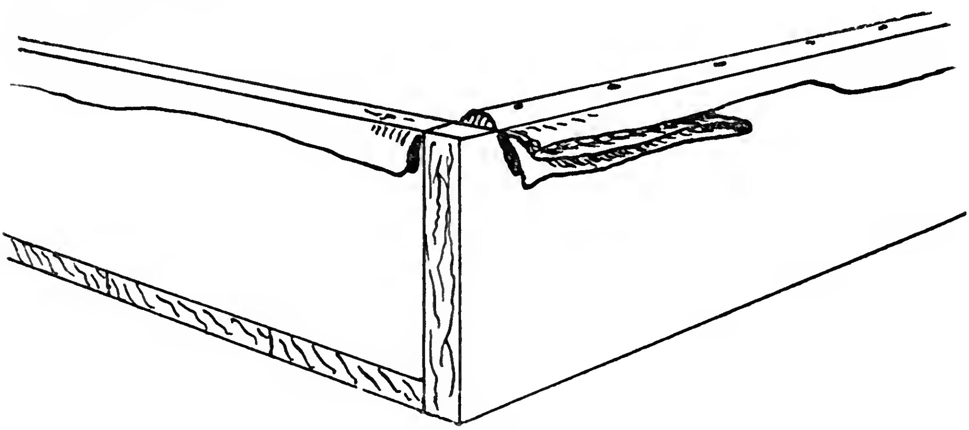


Fig. 38

If a developer is one not easily oxidized, such as Metol-Hydrochonon, it may be used a good number of times by keeping it in an air-tight glass carboy. Films may be dried upon the racks after washing but as the pins cause a kinking of the film it is better to construct some sort of a drying drum upon which the film may be wound for drying and washing.

One of the most compact outfits for the development of motion pictures is the Spiral Reel invented and manufactured by R. P. Stineman of Los Angeles, California. It consists of a metal spiral with a thread or groove which holds the convolutions of film in a loose roll, parts of which are far enough apart to allow the developing solutions to act upon the sensitive surface and yet not close enough for any of the layers of film to stick together. Two hundred feet of film can be wound upon a spiral twenty-three inches in diameter and completely immersed in two gallons of developer.

These outfits are made in three sizes having respective capacities of 50, 100 and 200 feet and consisting of three round tanks or trays nesting within one another and having one or more spiral wheels for holding the film to be developed together with a spindle upon which the wheel may be revolved and a wire screen turn table upon which the film is placed for winding upon the drying drum or upon drying racks. For use:

Place reel on stationary winding pin at convenient angle to film box so that film will slide smoothly into reel. Fasten end of film in slot in center of reel then revolve reel with left hand, using the right hand against outer edge of film to guide film into reel. When wound, fasten other end of film to reel with metal clip. Film should be firmly wound and securely attached with the clip.

Immerse reel in developer and move rapidly up and down several times to prevent air-bells. When using Pyro repeat this movement several times during development.

When development is complete, rinse, fix and wash film while still on reel. Water and Pyro should not exceed three inches in depth.

When thoroughly washed, lift reel out of water and drain for a few seconds. Release ends of film and place reel face down on screen in about four inches of water by grasping reel through finger-holds on reverse side. Agitate slightly and raise reel, leaving the film on the screen. Lift screen out of the water, place on stand with revolving top and wind film on drum to dry. Do not touch face of film at any time—always lift the reel by handle in center.

Don't try to put film in reel when reel is wet.

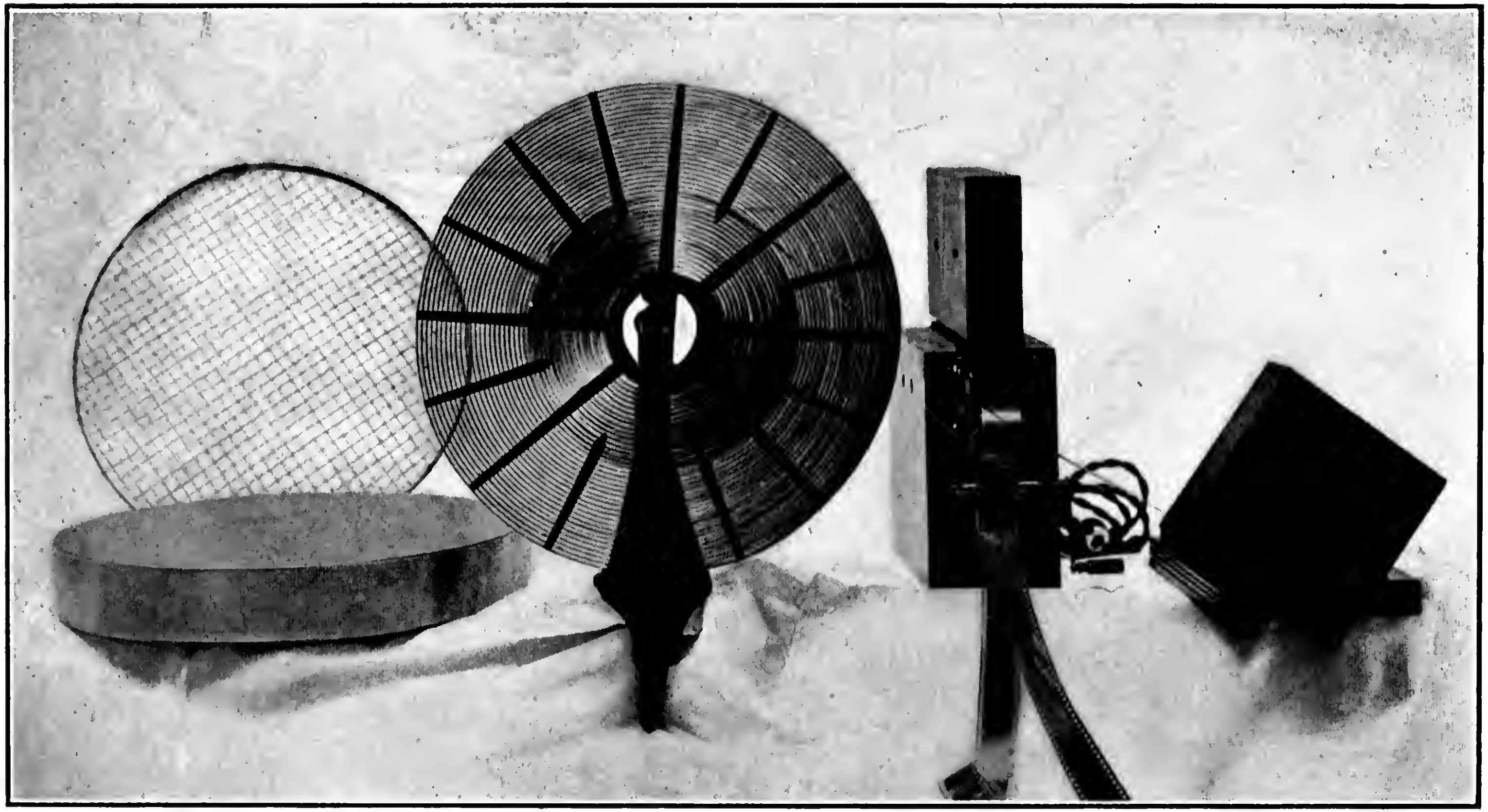
Don't try to take film from reel except by turning reel upside down in water.

Don't try to dry the film in the reel.

It is not necessary to use the screen with 50-foot film lengths—film may be rolled on core held by fingers.

## Exposure

The two greatest problems of both the still and motion photographer are correct exposure and correct development. These two things are shrouded in mystery even to many professionals—



(*Courtesy of R. P. Stineman*)

COMPLETE STINEMAN 100-FOOT DEVELOPING OUTFIT INCLUDING PRINTER

they may have learned by rule of thumb how to obtain good pictures but to save their lives they could not give the reasons for what they do. Also there are many false or erroneous ideas prevalent about exposure and development. One of the most pernicious of these false ideas is that an under-exposed negative can be "brought up" by special methods of development. Another is that different times of exposure require different methods of development. The truth is that the best development for under-, correct, and over-exposure is the same in each case.

The man who sets out to get a good negative every time will find that he has much to learn about development, and perhaps quite as much to unlearn. It has always been regarded as the critical stage in the making of the negative, an intermediate state where wonderful things could be done by those who knew how—"an art," as Bothamley said, "not reducible to a matter of figures." Hence the usual way of mastering development was to get this or that famous worker's formulae and method, and on that empirical foundation build one's own methods by experience. But, as Poor Richard told us long ago: Experience keeps a dear school. We are beginning to be wiser. The investigations of Hurter and Driffield plainly show that "the production of the photograph is governed by natural laws, and a definite effect must result from a definite cause. The same cause, under the same conditions, always produces the same effect. Only by clearly grasping and working in harmony with these laws can we really become masters of technical photography." Our first step, then is to seek that scientific knowledge which is a knowledge of things in their causes: to know, for instance, the law governing light-action.

Let us begin. When we make a photograph, our purpose is simple: to secure a record of some object of interest. The positive, then is the real end of all our photography. The negative is chiefly valuable or interesting as a means to the end, an intermediate step toward the positive—nothing more. Unless we get in the positive a record which truthfully describes the object photographed as the eye saw it, all our negative-making is in vain.

Many photographs are untruthful in their rendering of tone, misrepresenting the light and shade of the subject as seen by the eye. The reason why so many of our photographs fail to satisfy is here discovered; they do not give us the natural gradations of light and shade which please or interest us in the subject, and which are essential to the illusion of life and actuality. Our appreciation of truth in light and shade is not perfectly developed and we are not quick to recognize errors of this sort. Nevertheless, the technically good photograph of an object or scene in nature, which gives us the natural variety of light and shade in the subject, is invariably recognized with praise; while the bad pictures are simply passed by as "poor photography." For correctness of delineation in photography we are dependent on the lens and its right use. For the truthful representation of light and shade, we depend on the sensitive film and our use of its capacity to record the whole range of tones in the subject from highest light to deepest dark. In this discussion we leave delineation and the lens out of the question being wholly concerned with the other side of the problem: how to secure in the negative a faithful record of the light and shade effects of our subjects.

The consideration of light and shade, as exhibited in the objects we photograph, may seem for the moment to be somewhat remote from development of the negative. It is certainly the last thing thought of by the average photographer, and, even then, is usually considered as belonging to the pictorial rather than to the technical side of photography. As will be seen, however, it has a vital influence for good or evil in negative-making, and there can be little real success in technique until we grasp its practical importance and learn, like the professional photographer, to regard our subjects unconsciously as arrangements of light and shade.

To get at the significance of this point of view, let us consider the light and shade effects of any easily imagined subject simply as so many light-intensities—points reflecting light in varying degree at different parts of the subject, according to its illumination. If we mentally arrange these light-intensities in order according to their relative brightness or visual luminosity, remembering that in all pleasing transitions from light to dark the light decreases in geometric rather than arithmetic progression, we shall get, let us suppose, a scale ranging as follows: 64, 32, 16, 8, 4, 2, 1, which expresses a geometric series. On this imaginary scale the light reflected from the deepest shadow in the subject will be represented as 1, and the highest light in the subject as 64. Obviously, if the photograph is to give us a truthful record of the subject, it must include a range of tones from light to dark in which each tone is truly proportional to the light-intensity (or light reflected by that part of the subject) which it represents. In other words, the truthful representation of the light and shade of the subject demands that the tones or luminosity contrasts in the positive shall range from light to dark in geometrical progression, i.e., as 64, 32, 16, 8, 4, 2, 1.

For example: let us suppose that we are photographing three houses—a white one, a gray one and a black one—and that their light-intensity values (or relative visual luminosities) are, respectively, 5 for the black house, 20 for the gray one, and 80 for the white one. Here the progression of light-intensities is geometric, viz., as 1:4:16. The truthful representation of tone in such a case demands that the relationship between the three houses in the positive shall be proportional to the relative luminosity of the three houses as seen by the eye—i.e., as 1:4:16.

This applies in every instance. Whenever we see a photograph wherein the tones are true to nature, we may be sure that this relationship of *proportionality* exits. On the other hand, when we fail to secure this vital relationship between the light-intensities of the subject and the tones in the positive, our photographs are necessarily untruthful in their representation of light and shade. As the gradations of tone in the photograph result from the opacities in the negative, it is plain that a similar proportionality between light-intensities and opacities must pre-exist in the negative. Here we have the key to the truthful representation of light and shade in photgraphy. With this in mind we can go a step further.

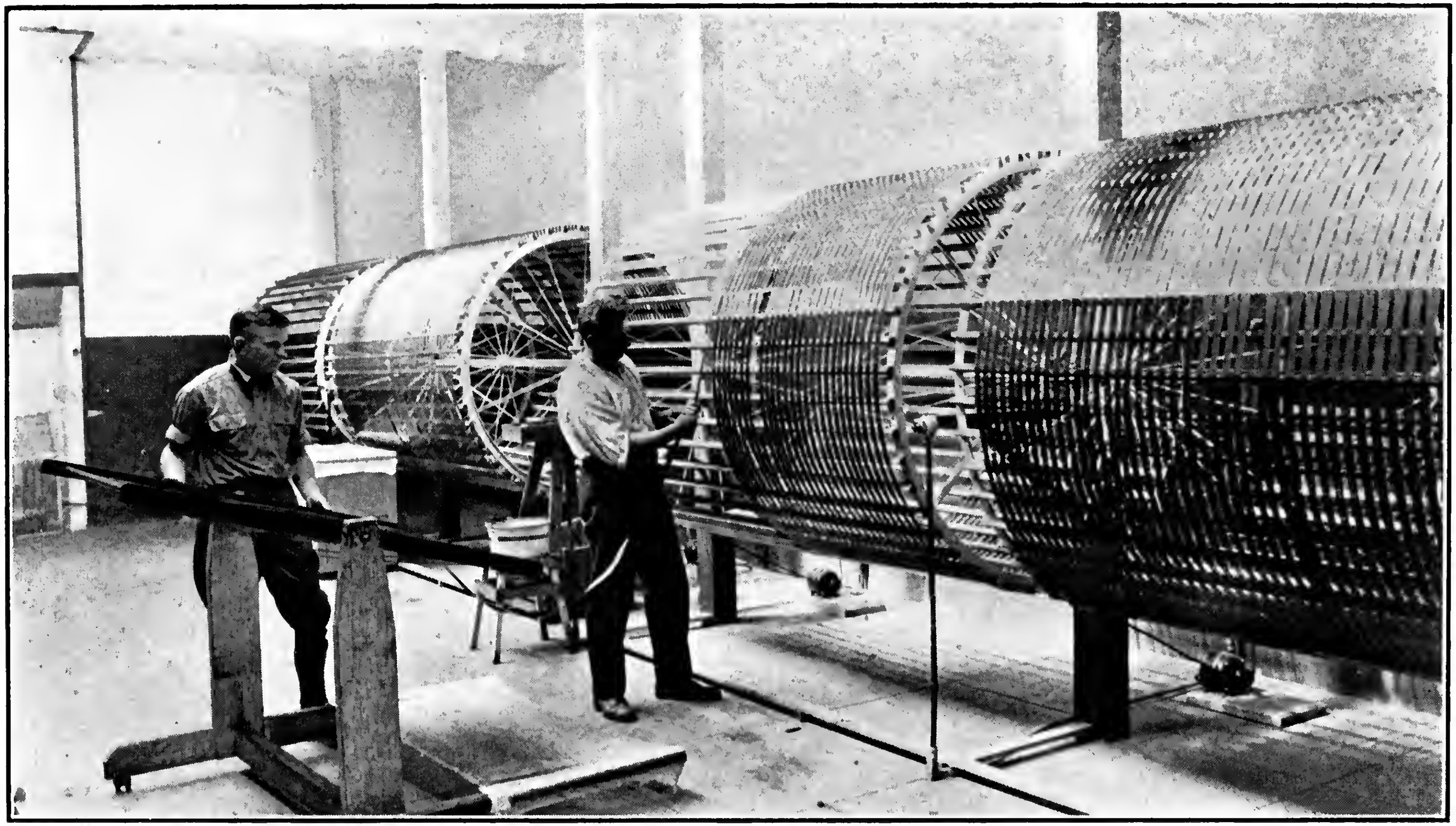
When we expose a film in the camera, the light-intensities at all parts of the subject begin at once to work a change in the sensitive film. The amount of work done (or light action) is, of course, determined by the intensity of the light at the same part of the subject. Thus, keeping aside for the moment all thought of the form of the thing photographed, the result of exposure is to impress on the sensitive film a latent range of gradations, distributed throughout the film and forming the latent picture image. On development, this latent range of gradations becomes a visible range of gradations, consisting of metallic silver deposited in the film by the reducing action of the developer. This is the negative.

Here we come to the parting of the ways. According to the old-school theories, success in negative-making depended chiefly on skill in development—always presupposing an exposure sufficient to give a developable image. The perfect negative was, of course the result of correct exposure and normal development. But the amount of control possible in development—by choice among developing agents, changes in the constituents of the developer, or modifications in the method of development—was generally supposed to be so large that, within wide limits, accuracy in exposure was a minor factor. Hence the widespread belief that a reasonably good negative could be had even though the exposure was much under or over the time correct for the subject. Hence the popularity of this or that developing agent or formula for which great claims were made as possessing peculiar capacities. The only indispensable condition of success was that one had to know how to choose the particular developer, how to work the changes required by variations in exposure, how to adjust, modify or control the rights and wrongs of exposure by skilful "tinkering" in development. Out of this system came all those innumerable formulae which bewilder the readers of photographic literature.

The beginner has little or no chance at such "tinkering" for success depends wholly on repeated trial and error. Hence the significant legend over the door of the dealer in photographic supplies: "We do developing and printing for amateurs." Whatever the virtues and conveniences of the typical old-school method —the tentative method of development—and despite its appeal to the vanity of "private judgment," there can be no doubt that it is based on an imperfect understanding of the functions of exposure and development.

The fallacies of these earlier systems and their lack of a rational basis is clearly demonstrated by the researches of Messrs. Hurter and Driffield. The system is not one which can be compressed into an intelligible paragraph, but, inasmuch as it forms basis of rational methods of development, it receives consideration here.

Briefly, then, that portion of the Hurter and Driffield system which concerns us is their investigation of the law governing the action of light on the sensitive plate, and its bearing on the functions of exposure and development. This investigation was undertaken by Messrs. Hurter and Driffield, as amateurs in



(*Courtesy of the Thomas H. Ince Studios*)

TRANSFERRING FILM FROM DEVELOPING RACK TO DRYING DRUM.

potography, to answer the question which lies at the heart of all negative-making: What is the law in obedience to which some photographs are true to nature and others are false? As a result of their researches, extending over years of work, they came to the conclusion that the truthful representation of light and shade in photography demanded a technically perfect negative.

This they define as one in which the opacities of its gradations are proportional to the light reflected by those parts of the subject which they represent. This all-important relationship between the opacities in the negative and the light-intensities in the subject depends upon the existence of a somewhat different logarithmic relationship between the light-intensity and the amount of silver deposited in development. The establishment of this relationship is, in turn, dependent on correct exposure. It should be clearly understood, however, that the term "correct exposure," as here used, does not imply that there is necessarily one exposure, and one only, which will give us this perfect negative. As we shall see later, most of the films used in photography offer considerable latitude in this respect, so that the necessity of accuracy in exposure does not confront us with unsurmountable difficulties.

It is important to note that, in speaking of the gradations in the negative, Hurter and Driffield separate the qualities of density and opacity as two distinctly different properties. These are often confused and spoken of as being identical, but this is a mistaken notion. By the density of the gradations in the negative is meant the relative quantity of silver deposited per unit area in development. By the opacity of the gradations is meant the optical property of the deposit to impede the passage through it of light. "Transparency" is, of course, the inverse of opacity, and is measured by that fraction of the original light which the deposit transmits. These qualities belonging to the gradations of the negative, as we have read, have relationship with each other and to the light-intensities which produce them.

At first sight all this may seem extremely technical and perplexing, but let use see how the system was worked out and many things will be made plain as we go along.

In beginning their investigations, Messrs. Hurter and Driffield took a thickly coated, slow plate and, using a constant source of light, made a series of exposures in geometrical progression—

i.e., 1, 2, 4, 8, 16, 32, 64 and so on doubling each exposure as they proceeded. This course enabled them to trace very rapidly the action of light through a large range of exposures on a single plate. On development, this gave a negative in which the suc-

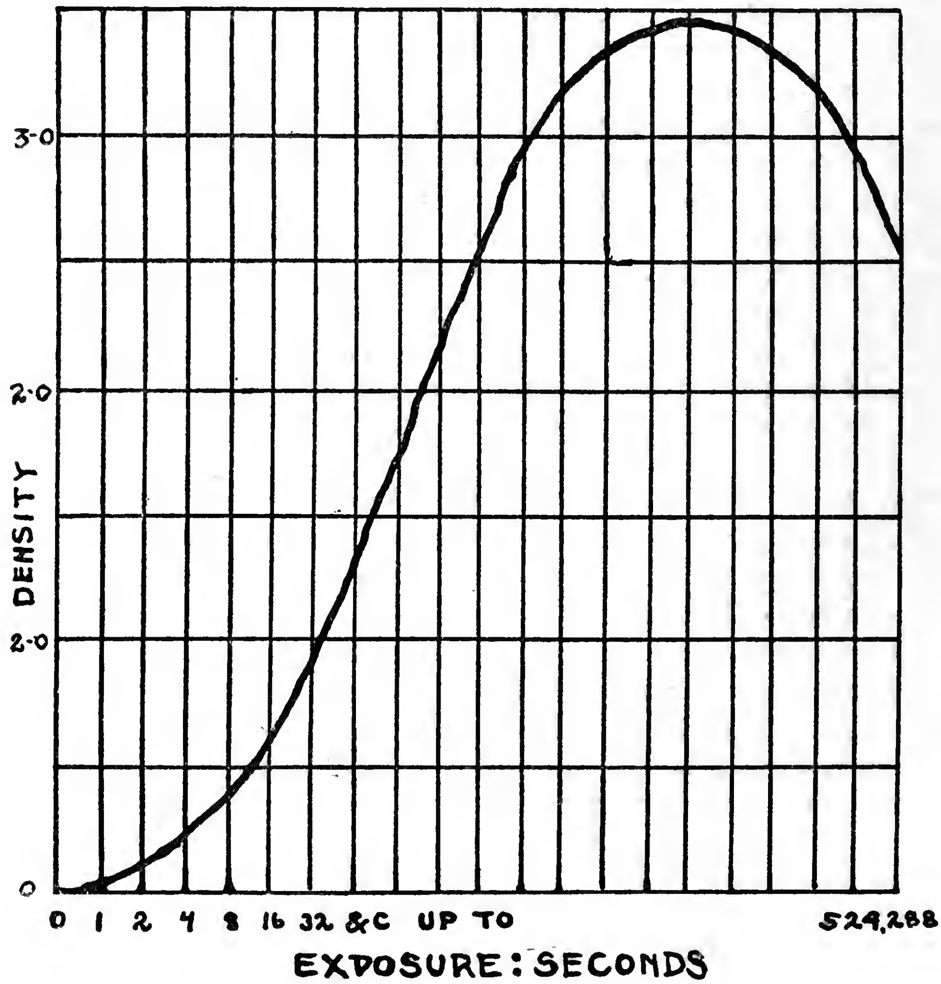



Fig. 39

cessive exposures were represented by a series of gradations. They then measured the densities of the gradations in their test negative, by means of a specially devised photometer. In this way they ascertained the actual weight of silver deposited corresponding to each successive exposure.

The density values thus obtained were plotted by points on a chart represented in *Fig. 39*. These points were then joined and resulted in a peculiar curve which they styled the "Characteristic Curve" of the plate, because it differs with each different brand of plates tested and also affords much information concerning the speed, capacity as regards the range of gradation, and the general character of the plate. It will be noted that the vertical scale in *Fig. 39* indicates density or amount of silver deposited; while the horizontal scale indicates exposure or light-density. It will further be noted that the horizontal scale progresses in geometric series, each successive exposure (equi-distant on the scale) being double the preceding exposure; and the vertical scale progresses arithmetically—i.e., as 1, 2, 3.

An examination of the characteristic curve shows that it consists of four distinct branches, gradually merging from one into the other. It commences with a strongly bent portion which then merges into a straight line; this gradually assumes a curvature in the opposite direction, until it reaches a maximum density, when the curve takes a downward course. The four distinct branches of this curve correspond with the phenomena of under-, correct and over-exposure, and of reversal, with which the practical photographer is familiar in his everyday work.

These distinctive periods in the action of the light upon the sensitive plate are due to the fact that the work done by the light, at any moment of the exposure, is proportional to the amount of energy received at that moment by the unaltered silver bromide; and as the silver bromide is gradually altered, the amount of unaltered silver bromide grows gradually less and less. But for this fact, the density of the gradations in the negative would be, throughout the entire range of exposures, proportional to the light-intensities, and truth in photography would be an impossibility. What we require is proportionality between the opacities and the light-intensities, and this exists only when the relationship between the densities and the light intensities is logarithmic. As we shall see, this relationship results from a correct exposure.

The significance of this growth of density in development and the relationship between density and light-intensity or exposure will perhaps be plainer if we represent it by a series of steps forming a peculiarly constructed staircase, as in *Fig. 40*, instead of the curve seen in *Fig. 39*. In this staircase we observe that three distinctly different conditions exist which represent the three periods of under-, correct and over-exposure respectively. The period of reversal may be neglected as of little interest in everyday photography.

Having regard to the "rise" of the individual steps in this staircase as indicating increase in density, we note that, com-

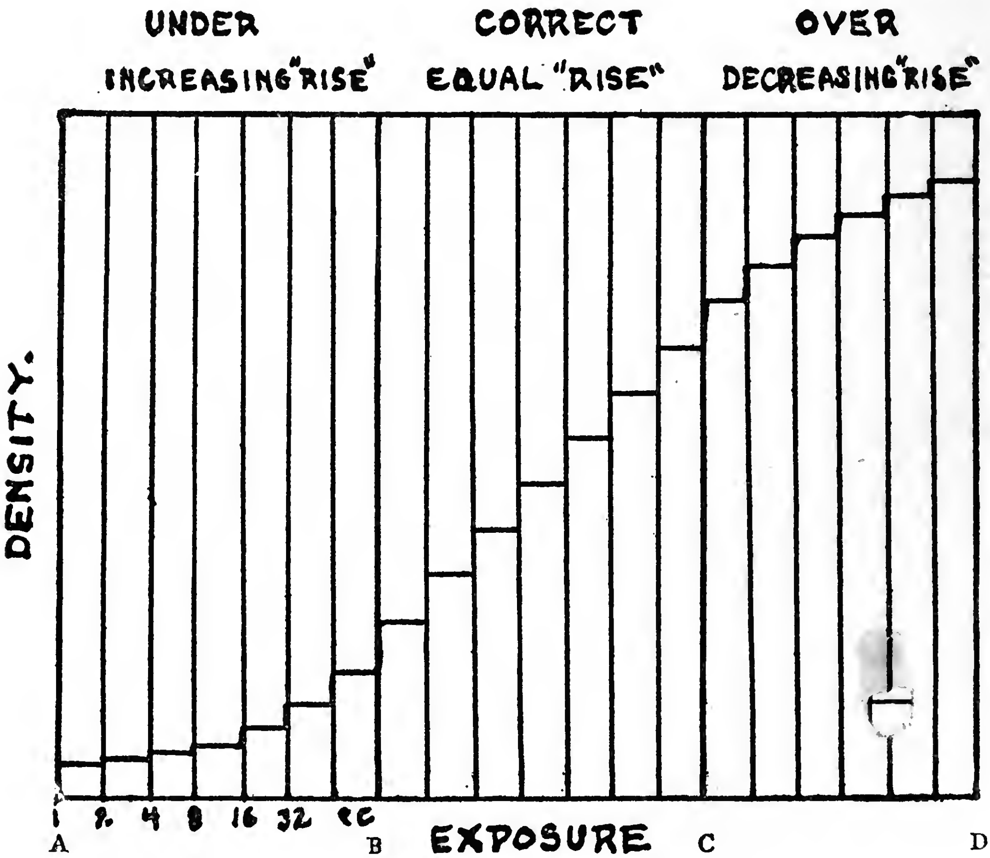
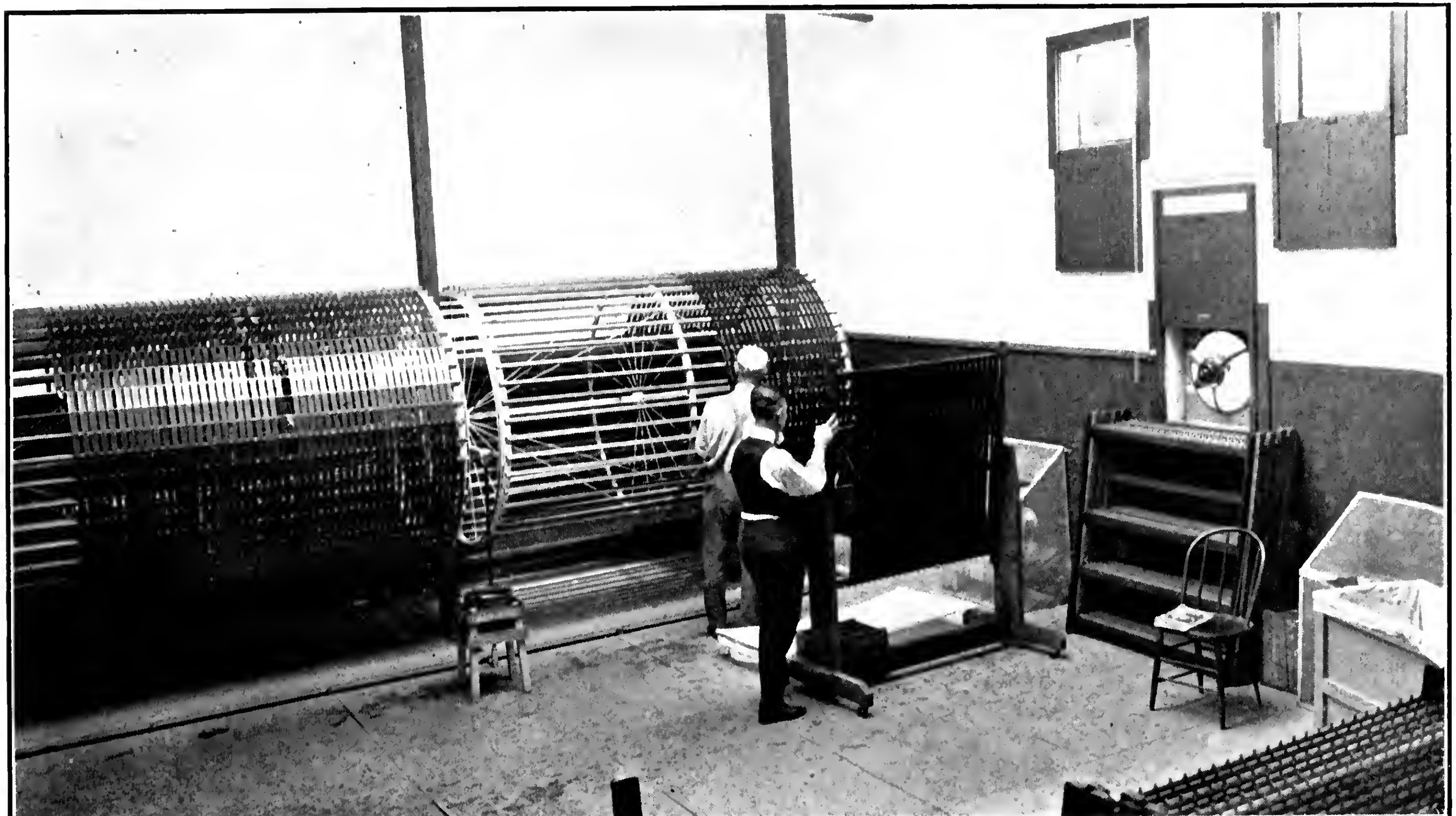



Fig. 40

mencing at A and proceeding as far as B, the steps are marked by a gradually increasing rise, but that at the very beginning of this period this rise is proportional to the exposure or light-intensity. Keeping in view the definition of a perfect negative as given before, it will be seen that we have here a false relationship. Proportionality exists between exposure and density, instead of between exposure and opacity. A negative, the gradations of which fall within this period, will represent the shadows and most of the half-tones of the subject by bare glass; while



(Courtesy of the Thomas H. Ince Studios)

NEGATIVE DRYING ROOM.

the high-lights will be marked by relatively extreme density—in other words, the negative will be under-exposed.

Next we note that from the point B, and extending to C, the steps in the staircase are ali of equal rise; that is to say, each doubling of the exposure is represented by an equal increment of density in the negative. Thus the density grows arithmetically while the exposure progresses geometrically. As the mathematician calls each term of an arithmetic series the logarithm of the corresponding term of a geometric series, it will be apparent that any exposure which falls within this period gives us that logarithmic relationship between densities and light-intensities which is essential to the truthful representation of light and shade. The following ratios will serve as an example of this relationship.

Light-intensities (exposure) 1:4:16 (geometric progression)
Silver deposited (density) 0:0.6:1.2 (arithmetic progression)
Opacity 1:4:16 (geometric progression)

Thus we see that the photographic plate is capable of giving a range of opacities truly proportional to the light-intensities of our subjects, but only on condition that all its gradations fall within that portion of the staircase (*Fig. 40*) in which the steps are of equal rise; or, in the case of the "characteristic curve," within that portion represented by a straight line.

Referring again to the staircase, the period of over-exposure begins at C and continues till the highest step is reached, when the period of reversal sets in. In this period, the growth of density is marked by a gradually decreasing rise in the steps, which finally becomes imperceptible. A negative, the gradations of which fall within this period, would be as false in its representation of light and shade, but in an opposite direction, as if its gradations fell within the period of under-exposure. The characteristic of under-exposure is too great contrast between the tones; in the period of over-exposure the contrasts are too small. The tendency of the gradations in cases of over-exposure is (as we see in the steps) to approach one uniform density; hence the flatness and lack of contrast in over-exposed negatives, in which the high-lights and half-tones are represented by almost similar opacities. Obviously, if the negative is to yield a positive true to nature, it must include no steps in the under- and over-exposure portions of the staircase, but its densities must fall within the straight portion of the "characteristic curve." This is secured by a correct exposure.

Having by means of a correct exposure established a true relationship between the latent gradations of the negative and the light-intensities, the function of development is to reduce the latent image to metallic silver. The average photographer would describe the process by saying that, as development proceeds, the negative becomes denser. Something more than this is involved, however, as the duration of development materially influences the result.

By conclusive experiment, Hurter and Driffield have demonstrated that, although the total amount of density increases as development is prolonged, the relationship between the densities, as established by exposure, remains identical and unchanged, whether the development be long or short. In other words, the density ratios are constant and independent of the time occupied by development. Thus, if we give three plates or films identical (correct) exposures and develop them respectively for two, four and six minutes, the total density throughout the gradations of the three plates or films will increase correspondingly with the time of development, but the relationship between the densities in each negative will remain unchanged. This lead to their recognition of the law of "Constant Density Ratios," which, once grasped, does away with the old-time misconceptions regarding the possibilities of control or modifications in development, either by changes in the developing solution, choice of developing agent or method.

But, though the density ratios are constant, the opacities which appeal to the eye do alter, both in amount and ratio, as the time of development is prolonged. Hence the range of light-intensities transmitted by the correctly exposed negative developed for four minutes will be far greater than the range transmitted by another correctly exposed negative developed for two minutes. The alteration in opacity ratios is not, however, variable or controllable at the will of the photographer, but they alter according to fixed laws; just as, by the same laws, we have seen that the density ratios are invariable.

From these explanations the reader will perceive that density forms the connecting link between exposure and opacity. In order to make the relationship between density and opacity, and again, between transparency and opacity, as clear as possible, we insert here a table prepared by Mr. Julius Martin, to illustrate this triple relationship.

The relation of density to opacity is numerically shown by the figures in column 2 of the table. Incidentally, a study of columns 1 and 2 will serve to illustrate the wide variation between density and opacity, and the growth of opacity as compared with the growth of density during development. The general belief that density and opacity are one and the same thing is here seen to be based upon a misconception. The relation of transparency to opacity from the corresponding values of density and opacity in columns 1 and 2 is seen in column 3 of the table.

TABLE

Showing the comparative values of density, opacity, and transparency, according to the Hurter and Driffield System of Speed Determination by Julius Martin.

| I. *Density* | II. *Opacity* | III. *Transparency* |
|---|---|---|
| .0 | 1. | 1. |
| .1 | 1.26 | .793 |
| .2 | 1.6 | .628 |
| .4 | 2.5 | .397 |
| .6 | 4. | .251 |
| .8 | 6.3 | .158 |
| 1. | 10. | .100 |
| 1.2 | 16. | .0628 |
| 1.4 | 25. | .0397 |
| 1.6 | 40. | .0251 |
| 1.8 | 63. | .0158 |
| 2. | 100. | .0100 |
| 2.2 | 159. | .00628 |
| 2.4 | 252. | .00397 |
| 2.5 | 317. | .00316 |
| 2.6 | 398. | .00251 |
| 2.8 | 631. | .00158 |
| 3. | 1000. | .001 |
| 3.2 | 1585. | .00063 |

| I. *Density* | II. *Opacity* | III. *Transparency* |
|---|---|---|
| 3.4 | 2512. | .000398 |
| 3.5 | 3161. | .000316 |
| 3.6 | 3982. | .000251 |
| 3.8 | 6310. | .000158 |
| 4. | 10000. | .0001 |
| 4.2 | 15850. | .0000628 |
| 4.4 | 25120. | .0000398 |
| 4.5 | 31631. | .0000316 |
| 4.6 | 39820. | .0000251 |
| 4.8 | 63100. | .0000158 |
| 5. | 100000. | .00001 |
| 5.2 | 158500. | .00000628 |
| 5.4 | 251200. | .00000398 |
| 5.5 | 316310. | .00000316 |
| 5.6 | 398200. | .00000251 |
| 5.8 | 631000. | .00000158 |
| 6. | 1000000. | .000001 |

The practical conclusions to be drawn from this discussion of the somewhat involved relationships between light-intensities, densities and opacities may be summarized as follows:

1. The truthful representation of light and shade in the photograph demands that the opacities in the negative shall be proportional to the light intensities in the subject.

2. This truthful relationship between the opacities and the light-intensities depends on the existence of a truthful (logarithmic) relationship between the densities of the negative and the light-intensities which can be established only by giving the film or plate a correct exposure.

3. It is the function of exposure to determine the relationship which shall exist between the densities and the light-intensities they represent. As established by exposure, and whether true or false, this relationship is unalterable by any modification in the developer or in development. If the exposure is correct, the densities will bear a truthful (logarithmic) relationship to the light-intensities and the opacities will yield a visible image (the positive) true to nature in its gradations. If, on the other

hand, the exposure is incorrect, the relationship established between densities and light-intensities will be false, and no modifications of the developer or changes in development can give opacities capable of yielding a positive true to nature in its gradations. Hence correct exposure is imperative as a fundamental condition for the production of a photograph true to nature.

4. It is the function of development to reduce the latent image (given by exposure) to metallic silver, and to determine, by its duration, the extreme range of opacities which the positive will include.

In other words, success in negative-making plainly depends on exposure and not on any special skill in development. It is worth a great deal to know this, and to know further that our belief is based on scientific fact. Obviously, this knowledge immensely simplifies all photography, making plain what we must work for and how to attain our end most simply and most surely.

Our first concern, then, must be to learn how to give our film a correct exposure every time. Having accomplished this, the only difficulty presented in development is to know when to stop, i.e., when the opacities exactly represent the ratio of the light-intensities in the subject. The necessity of a correct exposure, as already hinted at, need not unduly disturb the reader. For every plate or film there is a range of exposures during which the relation between the densities and the light-intensities is so nearly logarithmic that we may neglect the difference between truth and its approximation. The more richly coated the film, the wider is this range, and the more extended is the scale of gradations (or light-intensites) which the film can render truthfully. Thus this range expresses what we call the latitude of the film as far as exposure is concerned, i.e., the limits of exposure within which the negative will give a truthful record of the light and shade of the subject. This capacity of the film is obtained from the characteristic curve of the film and comprises the straight portion of the curve (*see Fig. 39*) or the period of correct exposure (*see Fig. 40*). Its extent varies with different brands of film; usually it is dependent on the amount of silver haloid in the film and is greater in slow than in fast films. Obviously, too, the latitude of exposure, in any film, is influenced by the range of light-intensities in the subject, and also by the degree of truth with which the contrasts of the subject are to be presented in the positive.

In *Fig. 41*, we have the characteristic curve of a film the range of which may be taken as 1 to 60. Any exposure which will include the range of light-intensities in the subject within these limits will be a correct exposure. As the total density of the negative increases with the exposure, however, the photographer will always aim at an exposure which will cause the gradations

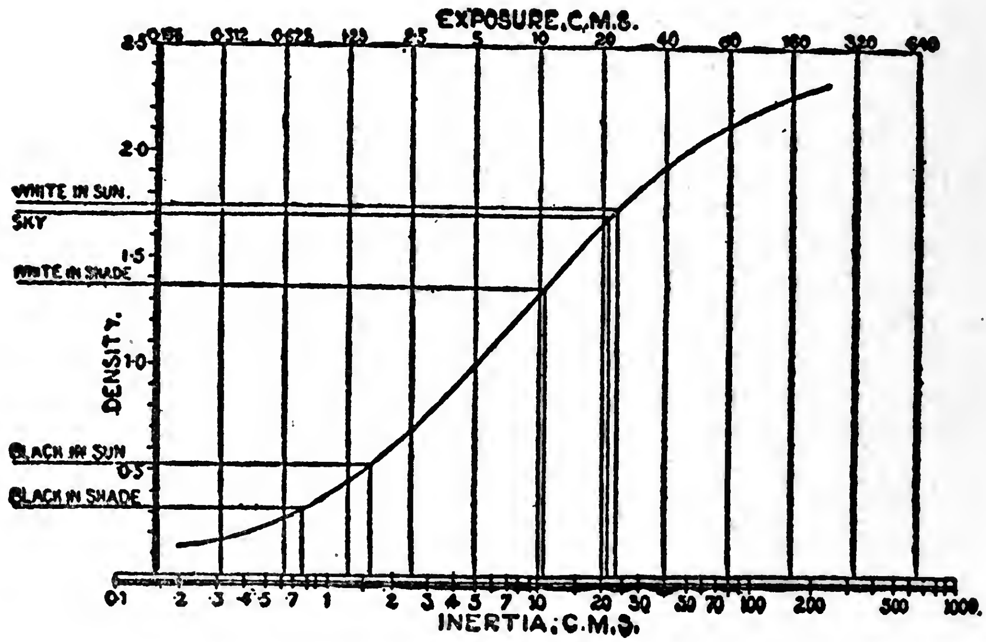



Fig. 41

of his negative to begin at the lowest portion of the straight line representing the correct period. The best possible negative is, of course, one which combines truthful representation of the subject with minimum density; but, owing to the practical difficulty of attaining absolute accuracy in exposure with widely different conditions, we can well content ourselves if we so manage that we get the gradations of the negative anywhere within the limits of the period of correct representation. This can usually be done with the aid of an exposure meter or reliable set of tables. It should always be remembered, however, that these give the shortest possible exposures under given conditions, so that exposures slightly in excess of the figures in the tables or indicated by the meter used will be advisable.

The range of light-intensities reflected by different classes of subjects is a matter about which many photographers are poorly informed. Messrs. Hurter and Driffield give the range of a subject including white cardboard in sunlight and black velvet in shade as 1:30. The latitude of the film shown in *Fig. 41* for such a range would be 1:3, that is the exposure could vary from 1:3. In interior photography the range will be less, allowing a correspondingly greater latitude in exposure. In portraiture the range of light-intensities is usually very limited, say 1:10, giving a still greater latitude in exposure without loss of truth in representation. Dealing with this Mr. F. Dundas Todd, a portrait photographer, has made a series of practically identical positives from negatives including exposures varying as 1:16. This may be taken as an exceptional instance, a safe range with the average plate or film being 1:4 or 1:5.

This must conclude our glance at the Hurter and Driffield system and its bearing on exposure and development. All mention of their advocacy of a numerical system for the expression of development factors and their methods of determining the speed and other qualities of plates or films must be omitted, to give room for the practical application of the principles herein discussed. The interested student will doubtless refer to the detailed information in more extended treatises on development which will be found listed in the chapter on bibliography.

With this knowledge of the Hurter and Driffield system and its basis, we can now begin to apply it in practical work. Since exposure is, as we have shown, the prime factor in negative-making, which determines once and for all its truth or falsity as a record of the subject photographed, it is plain that development is enormously simplified, being in fact merely a process which reduces the latent image to metallic silver, the truth or falsity of the record being determined by the exposure. In the following method of development worked out by Professor W. H. Wallace, development is reduced to its simplest terms. It gives us all that we can obtain by any other method, and at the same time gives us perfect control over the total range of opacities to be included in the negative.

This method is based on the principles of time and temperature development indicated in the Hurter and Driffield system, and also resembles somewhat the well-known system devised by Mr. Alfred Watkins, the "time of appearance" being omitted from consideration. It gives without unnecessary detail, and in the fewest possible words, a method and formulae which will enable the beginner as well as the expert worker to get the utmost from his exposures with the least possible trouble or chance of failure.

It should be noted that as no two brands of emulsion will work at just the same speed with any given developer, a trial or two may be necessary to get just the right degree of contrast with the film used. In this it is only necessary to remember that the range of opacities (or contrasts) is determined solely by the duration of development: the higher the factor, the greater the opacity or contrast. Once the correct contrast factor for a normal subject has been ascertained, it will not be necessary to change the factor except for some special purpose or for a different class of subject, according to the preference of the individual worker. Obviously changes in temperature, the only condition at all difficult to control in this system, may to a certain extent be compensated for by slight variations in the length of development.

For the preparation of the developer the student is referred to the chapter on How to Prepare Photographic Solutions, and for development formulae, to the appendix.

As the developing formulae given elsewhere in this book are not calculated with reference to this table it will be necessary to do one of two things in order to use the table. The simplest method is to test the developer with strips cut from a roll correctly exposed, and, using a small sample of concentrated solution at 70° Fahrenheit determine the proportion of water to add to make an average negative in three and one-half minutes development time.

When the proportion of water necessary is found—though it may be more or less in quantity than that given in the formula—this becomes the standard for use with the table.

The other method is to change the table instead of the developer. To change the table for your favorite developer make a test at 70° and note the development time. Suppose it is seven minutes instead of three and one-half. Then make a new table in which all the time values are multiplied by two (seven divided by three and one-half equals two). In a similar manner the multiplying factor for any other developer may be found by dividing the development time by three and one-half.

*(Photo by New York Institute of Photography)*

DEMONSTRATING THE MAKING OF TEXT STRIPS TO ASCERTAIN WHETHER EXPOSURE IS CORRECT.

The tanks and solutions used for developing should be kept in the same room where the work is to be done, so that they will all be at approximately the same temperature. Naturally, in this system uniformity in results depends largely on this factor of uniform temperature. It is also necessary to observe reasonable accuracy in making up the developing solutions. If the thermometer in the dark room hangs clear of its support, and there has been no recent severe change, the atmospheric temperature may be relied upon, otherwise the solutions should be tested just before beginning work.

Keep the solutions moving gently during development. The method of using the tables is as follows: Having prepared the developer and taken care to have the various solutions at approximately the same temperature, the temperature is first noted. Now find this degree of temperature in the first column at the left-hand side of the table and at the intersection of the horizontal line with the vertical line leading to the contrast factor desired, will be found in minutes and seconds the length of time to develop at this temperature. To illustrate: Suppose we are using the factor of 6 as giving us the desired range of contrasts, and that the temperature is 73° Fahr. At the intersection of the lines 73 and 6 will be found the figures 2 and 55, indicating the time of development as 2 minutes and 55 seconds. Similarly, if the temperature is 68° Fahr. and the factor 5 gives us the required range of contrasts, at the intersection of the two lines 68 and 5 will be found the figures 3 and 10, indicating that the time of development should be 3 minutes and 10 seconds. This is all we need to know. The film rack is immersed in the developing solution, agitated from time to time and at the end of the indicated time is taken out of the developer, rinsed in the short stop and placed in the fixing solution.

With regard to the choice of the contrast factor among those given at the head of the table, this must be determined by the personal preference of the individual as to the general character of the negative desired. Naturally this preference will be considerably influenced by the amount of contrast in the subject, this depending on the character of the subject and its illumination. In a normal subject such as a sunlit landscape, softness will be gained by choosing a low contrast factor, and crispness with a decided relief can be secured by the choice of a somewhat higher factor. In portraiture, where the range of contrasts is often small and softness is generally desirable, a low contrast factor is usually necessary. Contrariwise, in photographs of carvings in bas-relief, where the contrasts in the subject usually require emphasis, a somewhat higher contrast factor should be chosen.

Time and Temperature Table for Use with the Wallace Method of Development, the Time Being Given in Minutes and Seconds.

| **TEMP.** | **CONTRAST FACTORS** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fahr.** | **4** | **4½** | **5** | **5½** | **6** | **6½** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | |
| **64°** | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 9 | 9 | Min. |
| | 00 | 20 | 45 | 05 | 30 | 50 | 15 | 00 | 45 | 30 | 15 | 00 | 45 | Sec. |
| **66°** | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 8 | Min. |
| | 45 | 05 | 25 | 45 | 05 | 25 | 45 | 30 | 10 | 50 | 30 | 10 | 55 | Sec. |
| **68°** | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | 8 | Min. |
| | 30 | 50 | 10 | 30 | 50 | 05 | 25 | 05 | 40 | 20 | 00 | 35 | 15 | Sec. |
| **70°** | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | Min. |
| | 20 | 35 | 55 | 10 | 30 | 45 | 05 | 40 | 15 | 50 | 25 | 00 | 35 | Sec. |
| **72°** | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | Min. |
| | 10 | 25 | 40 | 55 | 10 | 25 | 45 | 15 | 50 | 20 | 50 | 25 | 55 | Sec. |
| **73°** | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | Min. |
| | 00 | 10 | 25 | 40 | 55 | 10 | 25 | 50 | 20 | 50 | 20 | 50 | 15 | Sec. |
| **75°** | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | Min. |
| | 50 | 00 | 15 | 25 | 40 | 55 | 10 | 35 | 05 | 30 | 55 | 25 | 50 | Sec. |
| **77°** | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | Min. |
| | 40 | 50 | 05 | 15 | 30 | 40 | 55 | 20 | 45 | 10 | 35 | 00 | 25 | Sec. |

Temperature should be kept as near 70° as possible.

As rack follows rack in the bath it gradually loses its strength so that after a certain number of racks have passed through the solution the next higher contrast number must be used to attain the same results as with the fresher bath. On account of the variation in the capacity of film developing tanks the number of racks which can be put through before increasing the development time can be determined only by experience. This of course should be plainly noted on the table which should be placed close to a red light in the dark room where it can be seen readily.

Developer standing in the tanks unused over considerable periods of time also deteriorates and allowance must be made for time deterioration the same as for amount of film developed.

### Difficulties Commonly Met With in Negative Film Development

EXPOSURE. With negative film the latitude of exposure is considerable. That is to say, if f-11 were normal exposure, the film would stand an exposure of f-8 or f-16 without being too much over- or under-exposed.

Light varies in intensity from hour to hour during the day and from month to month during the year. In winter, exposure during the middle of the day should be from two to four times longer than at the same hour of the day in midsummer. Exposures made near sunset at any season of the year would be from five to ten times longer than at noon of the same day.

Correct exposure gives a well balanced image in which the detail of the shadows is fully brought out before the high lights are over developed.

Over-exposure produces lack of contrast. If development is carried too far, negatives will have too much density and shadows and half-tones will be clogged. Such negatives will be dense printers and the resulting prints will lack brilliancy.

In an under-exposed film there is no detail in the shadows and if development is carried too far, high lights will become chalky, resulting in a black and white print having no graduation or middle tones.

The best remedy for too much over- or under-exposure is to make new negatives, timing same correctly. Where this is not possible, intensification or reduction will *help to a certain extent,* but the best results cannot be expected unless exposures are approximately correct.

Where there is any doubt as regards safety of developing light, same can be tested easily. Take a piece of film, cover half of it, expose to the developing light for two minutes and develop. If the exposed half is perfectly clear and shows no fog, the dark room light may be considered safe. If, however, exposed section develops fog, the dark room light should be covered with one or two thicknesses of post office paper or orange glass.

FOG. Fog is sometimes caused by oil, dust or a hazy atmospheric deposit on the lens. This would give a flat hazy image, which on forced development would produce fog.

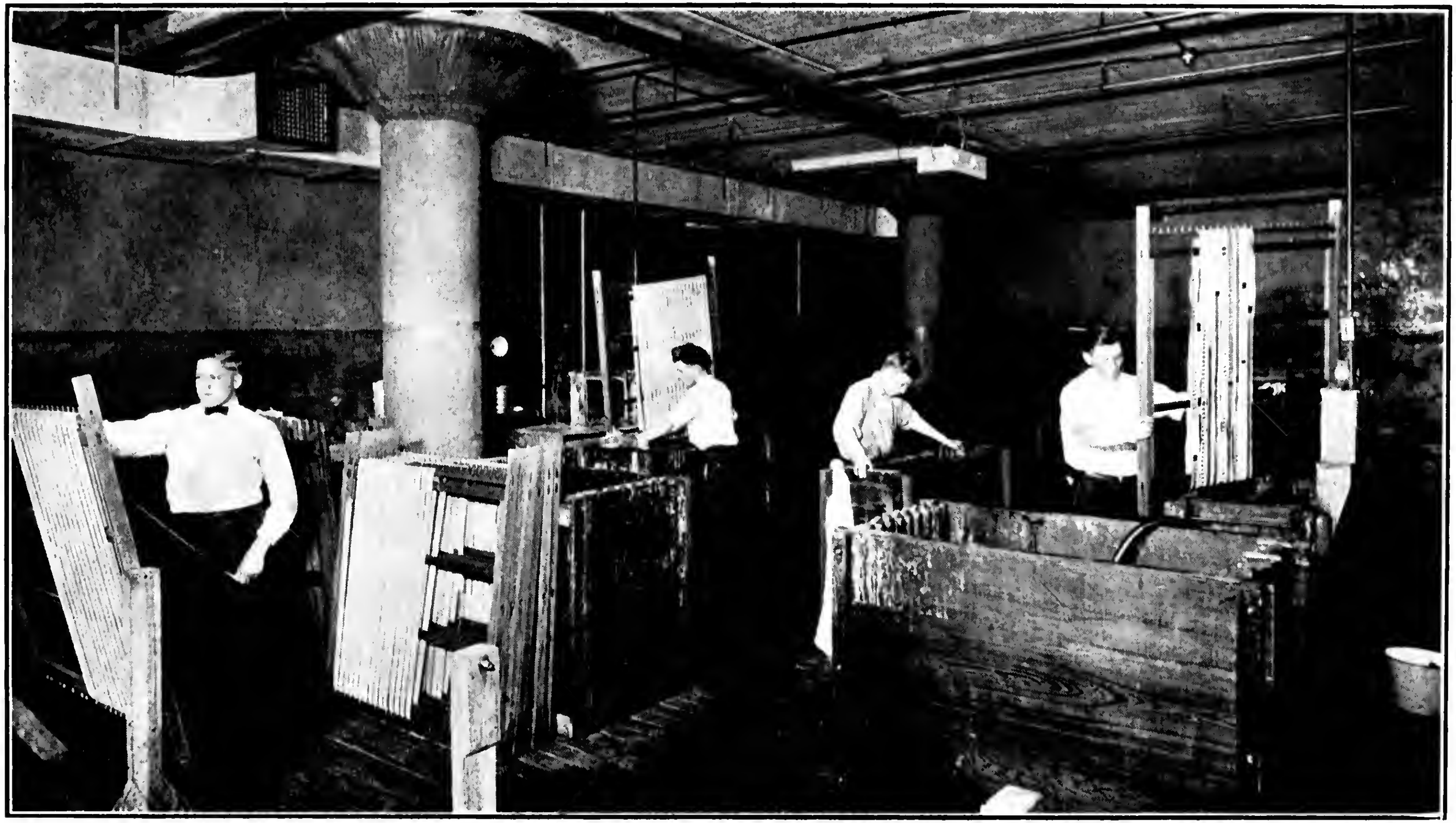
A uniform blackening of the film when developed, is due to fog. There are various kinds of fog and many different ways in which it may be produced. If film is exposed to an unsuitable dark room light during process of development, or when loading into magazines or winding on the racks, it will become fogged. Actinic light in the dark room is a most frequent cause of trouble and photographers sometimes blame the film when the difficulty is due to dark room not being light-tight, or developing light not being safe. Too much alkali or too warm developer will cause fog also. A leaky camera or magazine frequently cause fog.

The reversal of values whereby a negative is changed to a partial positive is not very generally understood. The most frequent cause for reversal of the photographic image is the exposure of the film to an unsafe dark room light during the process of development. The amount of reversal varies with the relation between the preliminary and subsequent development and length of exposure to actinic light after development has begun. Reversal occurs only when negative is fogged after being partially developed. Fog previous to development merely blackens the film all over.

Other causes for reversal are extreme over-exposure or a trace of Hypo in the developer. These latter causes are, however, infrequent. Reversal due to an unsafe dark room light is quite common and photographers not understanding the true cause, are usually inclined to blame the film.

HALATION occurs when strong lights are brought opposite dense shadows. It is frequently seen in the case of white draperies on a dark background. It occurs also when dark objects are photographed against a bright sky. When photographing interiors, halation shows as a spreading of the light from the windows. Another cause is reflection of light from the lens by some bright metal part of the mechanism or of the lens mount. All the interior metal parts of the camera, especially those near the lens and the aperture plate, should have a dull black finish.

THIN AND WEAK NEGATIVES lacking density may be due to under-exposure, developer used at too low a temperature,



*(Courtesy of Rothacker Film Company)*

SECTION OF POSITIVE DEVELOPING ROOM

or on account of developer not acting with sufficient energy. Thin, flat negatives are due also to insufficient development. Too much diffusion of light on the subject will produce flat negatives also.

The remedy would be to light with more contrast, giving more roundness and relief, give correct exposure and keep temperature of developer and dark room at the proper point. If, after having taken every precaution, negatives are still weak and lacking in brilliancy, it is possible that better negatives can be obtained by increasing the proportion of carbonate of soda in the developer. Impure sodas are responsible for many thin negatives.

FRILLING AND SOFTENING of the film is due to using developer or other solutions at too high a temperature. This causes the emulsion to soften and sometimes to lift from the support. Violent changes in temperature in the various solutions are liable to cause frilling. Frilling is, however, most frequently encountered in the summer time or in warm climates. The use of ice to keep the temperature at the proper point is recommended. Use fresh Hypo or an Acid Hypo Bath. Do not wash for too long a time and when drying, place negatives where there is a free circulation of air, so as to dry rapidly.

Negatives dried in warm, close atmosphere will increase in density and clog up the half-tones. The best way to dry negatives is before an electric fan, but under no circumstances should drying be hastened by the application of heat. Drying negatives in too warm a place will melt the emuision, causing same to run, giving a grotesque appearance to the image.

GRANULAR IDENTATIONS in the emulsion are due to slow drying. If negatives are dried too slowly the gelatine will swell and separate, causing transparent blotches and spots and a pitted appearance all over the surface of the film.

MOTTLED AND WRINKLED FILM is another kind of frilling. This is due to prolonged development, causing film to become soft, and then washing in water that is too warm. Wrinkling or reticulation of the film is most frequently due to its being left for a long time in solutions of too high a temperature.

A very common cause of blisters is not thoroughly rinsing film after removing from the developer and before placing in the Acid Fixing Bath. The developer being alkaline, transferring the film to an Acid Fixing Bath without sufficiently washing same, causes effervescence, and the gas forming under the emulsion, lifts the film and produces innumerable small blisters all over the surface of the film. The remedy would be to remove the alkali by rinsing before placing it in the fixing bath.

Negatives may be stained from a variety of causes. Brown or yellow stains, causing film to become discolored either entire or in sections, are usually due to imperfect fixing or incomplete washing after fixing. The use of decomposed Hypo or oxidized Pyro Developer will cause stains also.

YELLOW EDGE OR DISCOLORATION is frequently due to insufficient fixing and sometimes to insufficient washing.

The subject of spots is an endless one, and when this difficulty occurs it is usually necessary to consider each case individually. Some of the most frequent causes for spots are, however, as follows:

TRANSPARENT SPOTS may be due to an oily substance on the surface of the film which would repel the developer and prevent its action.

ROUND TRANSPARENT SPOTS with sharply defined edges are due to air bells in the developer which adhere to the surface of the film. This may occur either in tank or drum development.

SMALL SEMI-TRANSPARENT SPOTS occurring in tank development are usually due to effervescence in the water on account of high pressure. This causes minute air bells to adhere to the surface of the film during the preliminary stages of development, giving what some consider a mildewed appearance, but if spots are examined under a microscope, it can readily be seen that same are due to minute air bells, as above stated. The remedy would be to draw off sufficient water for developing bath, allowing same to stand long enough for the air to escape. The racks should be moved up and down during development to dislodge any bubbles that may form, and the top of the rack gone over with a large camel's hair brush saturated with developer.

IRREGULAR SHAPED TRANSPARENT SPOTS may be produced by scum on the surface of the developer. This occurs when using developer which has been allowed to stand and become oxidized. Irregular transparent spots are sometimes due to film having been injured on account of rough handling. In this case the emulsion will be found broken and dug through to the celluloid.

TRANSPARENT SPOTS AND PITTED EMULSION are due to the decomposition of the film, the result of slow drying in a close, heated atmosphere.

Opaque SPOTS WITH TRANSPARENT TAILS are due to dust on the plate and fogging caused by light shining in from a leak in the camera or magazine. Particles of dust resting on the film, if shiny or semi-luminous, have the effect of reflecting and concentrating the light on that portion of plate which is immediately in front of or beneath the particles, and then casting a shadow just behind the grains of dust. This produces the effect of opaque spots with transparent tails receding from them.

PIT MARKS, causing small transparent spots, may be due to sulphurous precipitation from the fixing bath. If there was an excess of alum used when making up fixing bath, and solution was not filtered or decanted off, precipitate would adhere to the surface of the emulsion and cause irregularity of surface if film were softened during subsequent washing.

PURPLISH OPAQUE SPOTS may be due to decomposed pyro or other chemical impurities in the wash water, or from dirty trays or tanks. Purplish black spots are due to particles of iron from the supply pipes settling on the surface of the negative. The remedy would be to filter the water, be sure that trays are clean and that no chemical impurity comes in contact with the surface of the film.

FINGER OR THUMB MARKS on the celluloid side of the film against which the emulsion side of the next convolution of film in the roll comes in contact, would cause spots, particularly if there was perspiration or a chemical impurity, such as Hypo, on the hands. These impurities would offset on the sensitized side coating and cause irregular masses of spots.

PECULIAR STAR-SHAPED MARKINGS sometimes appearing on film have been found to be due to colonies of bacteria. This has occurred when negatives were left in a damp, fetid atmosphere when placed on the rack to dry.

OPAQUE STREAKS may be produced by rubbing or other physical action on the film before developing. Opaque streaks are sometimes caused by tightening or "cinching up" a roll of film. If there were any particles of dust or organic matter resting between the surfaces, "cinching up" together would produce an opaque marking.

SEMI-TRANSPARENT STREAKS with sharply defined edges are due to not pouring developer over the entire surface of the film when developing in the tray.

TRANSPARENT MOTTLING is due to negative having partially stuck to the celluloid side of another turn of film during washing, and when pulling apart caused the emulsion to partially lift.

SMALL, SHARPLY DEFINED OPAQUE SPOTS have been caused in the dark room when allowing water to run from the faucet. The surface of the film became spattered either with clear water or by impurities from the bottom of the sink, and was afterward dried while awaiting development. This causes spots varying in size, character and intensity.

Numerous parallel vertical lines are produced by using decomposed pyro developer and acid in an old fixing bath, cutting the pyro stains out in streaks when precipitating. The remedy would be to use fresh developer and a new acid hypo bath.

(*Photograph by the Signal Corps School of Photography, U. S. A.*)

OPERATING DUPLEX PRINTING MACHINE.

## Chapter X

# MAKING MOTION PICTURE POSITIVES

HAVING described the methods of making the negative record picture in the motion picture camera, we come now to the processes involved in making the positive print. Many persons, who have not given any thought to the matter, have an idea that the film which comes from the camera is the same film which is run through the projection machine. If one stops to think for a moment, however, he will readily see that the developed film from the camera is a negative, and while it is possible to run it through a projection machine for examination, it has a peculiar appearance on the screen, showing light objects as black and black objects as white.

In order to show the proper relation of light values, it is necessary to make a print from this negative just as it is necessary to make a paper print or positive from a kodak negative. It is generally desirable also to make a number of duplicate copies from a single negative, so that the same picture may be shown at the same time in various places.

There are methods of making a positive direct in the camera, but these methods are only practical in certain isolated instances, which will be described more fully in another portion of this book.

Printing from a motion picture negative is not as simple a process as printing from a still picture negative, since the exact relation of distance of one picture to another must be preserved throughout the many feet of film. Most cameramen will not have the time or the inclination to make prints from their own films, but it is very desirable that the camera operator be conversant with all of the processes of finishing.

Since motion pictures are shown in a projection machine by means of light projected through the picture, it is necessary that the prints be made upon transparent film instead of upon paper as is the ordinary print. To make these prints as accurately as is required, a printing machine is necessary. There are quite a number of different machines for this purpose, all of which are constructed on the same general principle. They may, however, be classified under the two general heads:

Step printers and Continuous printers.

The mechanism of the step printer is essentially the same as the mechanism of the camera, except that instead of the lens, it has a light-proof box containing a printing light for impressing the negative image upon the positive, the negative and positive film being fed through the gate at the same time. The negative and positive films are placed in rolls upon spools or spindles above the gate and are fed down by means of a tooth sprocket which engages the perforations. The negative film is placed nearer the light with the emulsion side away from the light and the positive film with the emulsion toward the light, so that the two emulsion surfaces come in contact face to face. A loop is left between the gate and the feed sprocket as in the camera—the positive film having a slightly larger loop than the negative so as not to interfere with it as the films are drawn down in contact. A pair of pins or claws draw the two films down to go into the gate and pass the aperture through which the printing light shines. As in the camera, a shutter cuts off the printing light during the time that the film is being drawn down and then opens and permits the printing light to impress the negative image upon the sensitive positive film.

There are several reasons for this. We are not always able to control the amount of light which we need for taking a picture, but in the printing machine we have a light which we can make any desired strength.

We can impress the image from the negative upon the positive emulsion easily and quickly without having it nearly so sensitive as the negative stock so can use much stronger red light in our printing and positive developing room. Therefore positive stock is handled with much greater ease and certainty and by employees of less skill and training than is required for negative. The less sensitive positive stock is also much less liable to fog and gives a much clearer and more transparent print than would be possible upon the more sensitive negative emulsion.

A printing machine is run much slower than a camera. The printing rate has nothing to do with the rate with which the positive film is run through the projection machine, so gives time to conduct the operation of printing carefully and with due regard for the preservation of the precious negative film which may have cost large sums to produce.

The operation of printing machines is conducted in a photographic dark room where many of these machines may be in operation at the same time. The pressure plate over the printing aperture is generally made of ruby glass, so that the operation of printing may be inspected while it is going on without allowing any of the actinic light from the printing lamp to penetrate into the dark room. In most cameras, the pressure plate on the gate is held in continuous tension against the film by means of springs, but this cannot be done in a printing machine, as the continuous friction of the pressure plate upon the negative, after it had been run for a number of prints would surely scratch and scar the negative, and these imperfections would in turn be printed upon the positive film. For this reason, a mechanism is provided in the printing machine for releasing the tension upon the pressure plate while the film is being drawn down, but which allows the pressure plate to come back into contact during the time of the printing; that is, during the time that the film is at rest. This is done to insure perfect contact between the negative and positive film, otherwise, if they were not in perfect contact, the light from the printing lamp after passing through the negative would be diffused before it reached the positive and would not produce a perfectly sharp clear picture upon the positive emulsion.

The two films after passing through the printing gate, again form two loops and pass over the teeth of the take-up sprocket, and are wound upon two separate take-up rollers. The negative film is re-wound for passing again through the printer and the printed positive is sent to the positive developing room for development.

As the tension of the take-up on the negative film has a tendency to produce wear and abrasion, especially when dust or dirt settle upon the film, it is a common practice in some laboratories to dispense with the negative take-up and feed the negative film as it comes from the printer into a cloth-lined box or bag, from which it is carefully re-wound by hand. In other places, both take-ups are dispensed with and the positive film is also run into a separate receptacle before being wound up for transmission to the positive developing room.

Step printers are commonly operated at a speed of from three to four frames per second, which is as fast as is consistent with high-grade work. The steadiest positives are produced by step printers as the claws draw the film down exactly the same distance each time. Step printers are especially valuable where some slight difference exists between the perforations upon the positive and the negative film, since any slight difference is being constantly compensated for between the printing of each frame.

Take a concrete example:

We might have a piece of negative film which had so shrunk during the process of development that there were sixty-five perforations per lineal foot, whereas the undeveloped positive which might have been perforated upon the same machine contains sixty-four perforations to the foot. The claws of the printing machine would still enter every fourth perforation of both the positive and negative, and as each frame was printed the positive film would be drawn down one-sixty-fifth of the distance between two perforations further than the negative film. In other words, 64 feet of negative film would be printed upon 65 feet of positive film and yet each piece of film would have the same number of pictures and the same number of perforations, and the pictures upon both films would be equi-distant from one another, and each frame would have been in perfect contact while being printed.

Continuous printers do not have pins or claws to pull the film down one picture at a time, but the two films are fed past a slit at a steady even speed by means of a sprocket. It can readily be understood that unless the negative and positive in a continuous printer have exactly the same number of perforations per foot that there will be a small but constant shift between the surfaces of the two films causing a slight blurr in the film.

As negatives are of different densities and printing machines run at a uniform speed, it is necessary to have some means of changing the strength of the light to correspond with the density of the negative and give an even positive print. There are different methods of accomplishing this in different printing machines.

The methods are as follows:

The first is by varying the distance of the light from the printing aperture, which is accomplished from outside the lamp house by some mechanical device.

(*Courtesy of Rothacker Film Company*)

PRINTING POSITIVES WITH DUPLEX EQUIPMENT.

The second is by varying the strength of the electric current supplying the printing lamp. This is done by a rheostat, or variable resistance placed in series of the lamp circuit.

A third way is by varying the arc of exposure opening in the shutter.

A fourth is by means of a condensing lens placed between the lamp and the printing aperture and moving the lens system instead of the lamp. This permits of a smaller lamp house than the first method of moving a lamp, as a very small movement of the condensing lens will produce the same amount of change as moving the lamp for a considerable distance.

A fifth way is one which can only be used in the continuous printer. It is varying the width of the slot past which the film passes as it is printed.

When a new negative comes in to be printed, it is necessary to find just what strength of light is needed to print each scene. In large laboratories, this work is in charge of a man called a timer. Some of these timers become so expert through long experience that by mere inspection of a negative, looking at it toward a light covered with a ground glass, they can tell exactly how to set the printing lamp to produce a good positive. Some of them have a test chart which consists of negatives of all different densities mounted upon a sheet of ground or opal glass, and comparing these known samples with the negative brought in, can ascertain the correct printing time. "Correct printing time" is the term used, although it is not accurate as all of the machines in a factory run at the same speed or time. What it really means is the strength of the printing light.

None of these methods, however, can be absolutely accurate. An almost imperceptible change in the color of the negative deposit will need quite a different printing light from that of another negative of the same apparent density, but of slightly different color.

These methods, however, work very well in places which do all of their own developing where the negatives are apt to be of uniform color.

In commercial laboratories, negatives are developed under many different conditions with many different formulae and with deposits of different colors. A brownish pyro-developed negative, or one developed in an old developer which has left a slight brownish or yellowish stain, requires a considerably stronger light than a blue-black negative developed say—in a fresh metol hydroquinonine bath.

If the timer is in doubt as to the exact strength of light to use, he prints a test film about a foot long, using a range of lights from stronger to weaker than the one he judges will be correct. He then develops this test strip and determines from it the exact strength of light to use. Most printers are now equipped with what is called an automatic light change; that is, a mechanical or electrical device for automatically changing the light for each scene.

The automatic light change is actuated by an electrical contact on the machine which bears upon the edge of the negative film. By means of a special punch, a very slight nick or indentation is made in the edge of the negative film where a light change occurs. A small wheel connected with a delicate electric switch bears upon the edge of the film. As long as the negative film has no indentation upon its edge the light strength remains the same. When a light change is to occur, the small wheel depresses itself into the indentation by means of a spring and closes the electric circuit causing the light shift to advance one step. At each step the light will be shifted according to a hole punched in a control card. Each of these control cards has enough steps to shift the light for all of the different scenes which might occur in a two hundred foot roll of negative.

As the developing racks hold approximately two hundred feet of film, negatives to be printed are joined as nearly as possible to produce rolls of about two hundred feet. These control cards are punched by the timer or head printer so that each successive scene will be printed by the proper strength light.

On each roll of negative to be printed, a piece of leader is cemented, marked in india ink with the numbers or other identification marks showing what is contained in the roll, also marks showing the frame line, so that the printing may be started in correct register.

Negatives taken with different cameras often have different frame lines, that is, the line separating the frame in one film occurs in a different relation to the perforation on the edge, than it does in others. Printing machines are equipped with a framing device; that is, the distance between the claws and the printing frame may be altered so that each frame comes in exact register with the printing aperture. This framing must be done in all step printers, otherwise the line between the printed frames would come across the picture in the frame. The identification marks upon the negative leader are thus printed upon the ends of the positive film and remain there for its identification until it is ready to be assembled into a reel. The control card for each negative roll is marked with the same identification number as that on the negative roll and is filed away with it, or in a card-index drawer where it can be found readily when more prints are to be made from that negative. As seventy-five to one hundred duplicate prints are frequently made from an original negative and reprints may be called for at any time, it will be seen that such a system is very important and necessary.

Of the two types of printing machines just referred to the ones most used in this country are the Duplex, a step printer, and the Bell and Howell, a continuous printer. Since they are representative of designs of these types and most commonly met with in film laboratories, brief directions for their use are appended to the chapter.

## OPERATION OF THE DUPLEX PRINTER

The threading is simple. The positive stock is placed on the front disc and the negative on the rear disc. The ends of both films are led under a roller above the feed sprocket then over the feed sprocket and under the tension roller which maintains the film in position on the sprocket. A four-inch loop is left in the negative strip and a five-inch loop in the positive strip, the latter being nearer the operator. The difference in loop size is to prevent scratching from friction of one surface upon the other.

The films next pass through the tension box which is a continuation of the aperture plate and is located just above the gate. A spring contact attached to the track at one side of the tension box bears against the edge of the negative as it passes this point and serves to operate the light-changing mechanism by making contact through notches cut into the film near points where changes of scene occur. The width of the film track in the tension box is adjustable, thus making it possible to operate the light-changing device even though the negative be considerably shrunken.

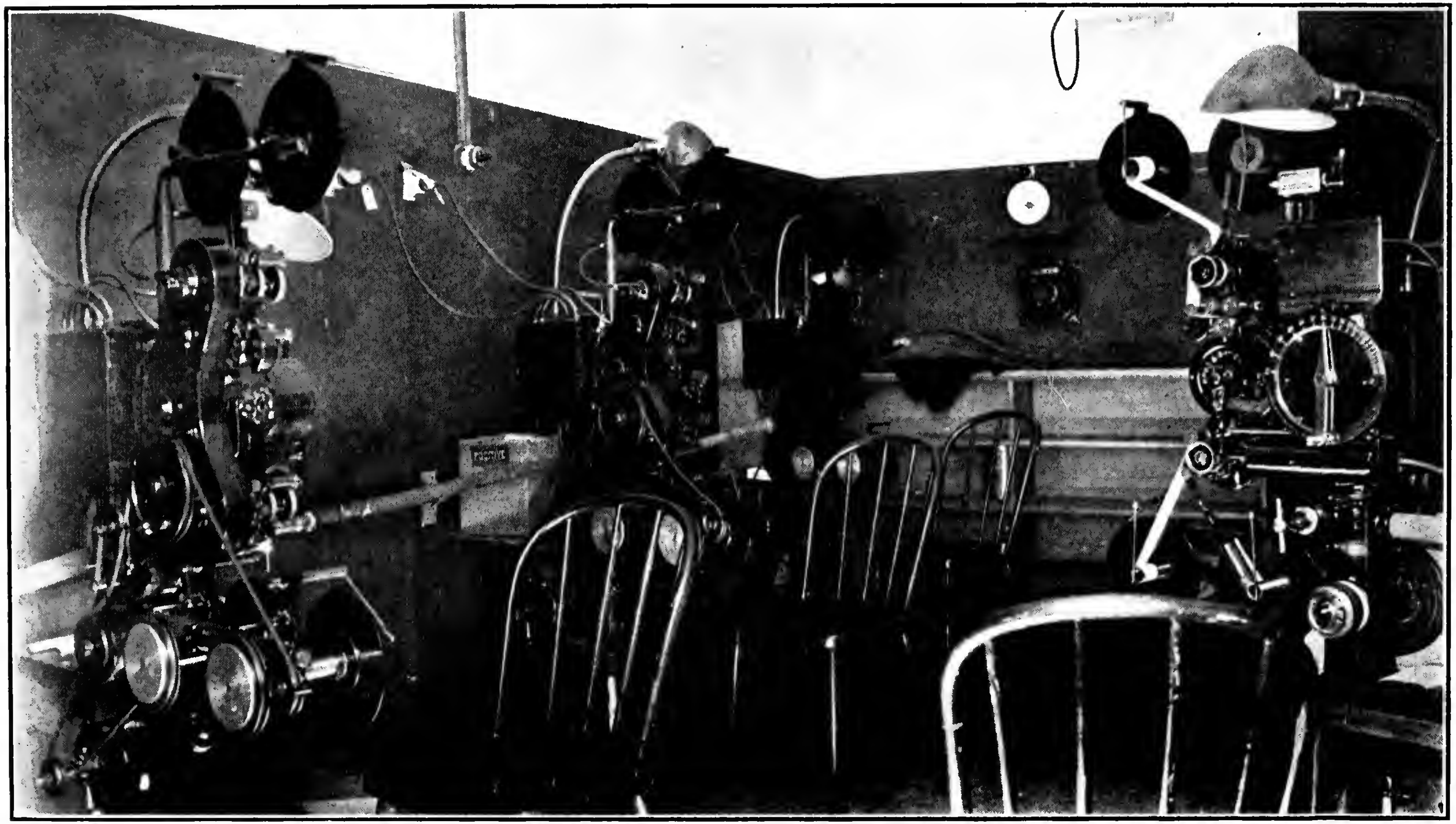
After passing through the aperture plate another pair of loops are formed, this time the positive being four inches and the negative five inches. The films after being passed under the tension rollers adjacent to each sprocket are run over the sprockets and then attached to the take-up spindles.

A highly perfected type of "automatic" now accomplishes the work of altering the printing light to suit the densities of the various scenes of the negatives being printed.

The light-changing movement consists of an accurate escapement which is operated by an electro-magnet very accurately wound so as to operate the escapement instantaneously when a contact is made at the breaker-box. The intensity of the printing light is controlled by a light bar which is so operated that it comes successively into contact with a series of plugs on the front of the automatic corresponding to the various scenes on the negative strip. Each of these contacts puts the requisite amount of resistance in series with the printer light, and it is thus that the printing intensities are governed. This automatic has a capacity of 18 different light intensities and will also change the light for 18 successive scenes at one sitting.

When the proper printing intensities have been ascertained for each scene of a given roll of negative, a card is punched with a series of holes corresponding to these light values. The card is then mounted on the front face of the automatic and plugs are inserted through the holes in the card, which is only used as a guide to the insertion of the bronze plugs, and may be removed before printing is commenced.

With the older types, the light-bar was in contact all the way across the front of the contact panel, but with the present model only one of the contact buttons on the inner side of the light-bar is in contact with one contact plug at any time. This allows the bar to drop so easily, when the automatic is operated, that a greater pressure can be supplied to its buttons, which assures excellent contact between them and the plugs through which the light changes are accomplished, and also eliminates any possibility of arcing when the light-bar drops from one position to the next. Electric current is supplied to the magnet which operates the escapement and light-bar of the automatic by the starting clutch of the printer, and is cut off, when the printer is stopped, through the medium of a switch which operates in unison with the clutch



(*Courtesy of the Thomas H. Ince Studios*)

CORNER IN THE PRINTING ROOM OF INCE STUDIOS. BELL AND HOWELL PRINTING MACHINES.

handle. If the machine is run without a negative film in place, the breaker-box will supply a continuous current to the magnet which might cause it to burn out, but this is avoided by disconnecting the flexible wire cord and plug through which the current reaches the automatic. The current is cut off from the printing lamps when the light-bar is opened for the insertion of the card and the contact plugs, while the current is in turn cut off from the light-bar by opening the switch shown at the bottom of each automatic. If the current is left flowing through the light-bar a shock can be sustained if the hands of the operator come into contact with it when arranging the contact plugs. In former models the light-bar was exclusively shifted by electricity through the medium of the contact in the breaker-box above the machine gate, but the perfected escapement of the new automatic terminates in a handle at the top by which the light-bar can be raised or lowered by hand to any desired position.

A film-notching device supplied with the printer is used to cut notches in the edge of the film at any point where a change in the printing light is required. This notching device is provided with a gauge which indicates the exact point at which the film should be notched, in order that the change of light shall occur exactly at the dividing line between scenes, and the rapidity with which the new automatic operates, insures freedom from long sections of improper density following changes of scene in the finished prints.

## OPERATION OF THE BELL AND HOWELL PRINTER

The essential factors necessary to the effectual realization of the continuous printing are:

*First*—Ability to maintain correct registration on the undeveloped positive stock, regardless of age or amount of shrinkage of the negative.

*Second*—A movement that will facilitate the continuous passage of the films over the light aperture without undue friction or abrasion.

*Third*—The flexibility of the volume of light used for printing scenes of different density and the rapidity of the changes from one intensity to another.

*Fourth*—The speed of operation or the actual capacity per working day, which is the most striking feature of this machine in comparison with other types.

Referring to the first problem relative to correct registration of the films regardless of shrinkage due to development: In order to bring the sprocket holes of the negative and positive stock in proper alignment and to offset the difference in length of the developed and undeveloped films it was necessary to construct the path followed by the two films past the exposing aperture to conform to the arc of a circle whose diameter is such that when the positive and negative are in position upon it, with the undeveloped or positive on the outside, the shorter length of the shrunken negative is counter-balanced by the decreased length of its arc over that of the positive. The perforations are therefore made to coincide and all creepage due to longitudinal shrinkage is overcome.

Now to take up the matter of lateral shrinkage or the shrinkage in width of the negative. It is obvious that guide rails along the film path are absolutely useless as the width of the positive film keeps these rails from bringing pressure to bear on both margins of the negative and hold it parallel with the positive stock. Therefore, some means had to be devised to bring about this condition without contact with the moving film other than through the medium of the driving sprocket teeth. With this end in view a sprocket was designed whose teeth on one side are built to conform with the standard perforation hole, being less than two thousandths of an inch smaller in width so as to completely occupy the opening, while the teeth that engage with the other margin of the film are slightly smaller in width in order to compensate for lateral shrinkage. Thus it will be seen that when two films are superimposed on this sprocket the perforations of the positive are held directly over and made to coincide with those of the negative, side movement being eliminated by the absolute filling of the sprocket holes along one margin of the entire length of the films by the sprocket teeth.

In taking up the second clause relative to a film movement permitting a constant pressure to hold the films in proper contact at the instant of exposure, it is obvious that any device with such a small area bearing on the continuous moving film, and of a sufficient tension to insure perfect contact, would produce the much loved enemy of the producer, namely scratches. Therefore, some means had to be evolved to overcome this difficulty, and the only available solution was to recess the aperture shuttle segment a point of contact with film and also to use, virtually, a cushion of compressed air, which was previously strained through silk mesh to remove dust particles.

By use in the light chamber, of a constant pressure of air whose only means of exit is through the exposing aperture and against the negative holding it in perfect contact with the positive, the question of scratches was entirely eliminated.

By careful consideration of the third problem mentioned relative to the varying strengths of light needed for consecutive scenes of different densities, it was found impractical to use an electrical resistance to diminish or increase the volume of light, owing to the fact that a slight decrease in the current supplied to the lamp greatly changes the quality of the light rays emanated, namely, from one of a pure white on full voltage to one consisting mostly of yellow rays on inserting a resistance. It is seen that very little latitude is available by using this method of changing and one of a mechanical nature had to be adopted instead of electrically controlled. Practical results were obtained by maintaining a constant radiation from the lamp and by increasing or decreasing the actual width of the exposing aperture similar to a focal plane shutter, which is the equivalent to varying the length of the exposure rather than the intensity of the light used.

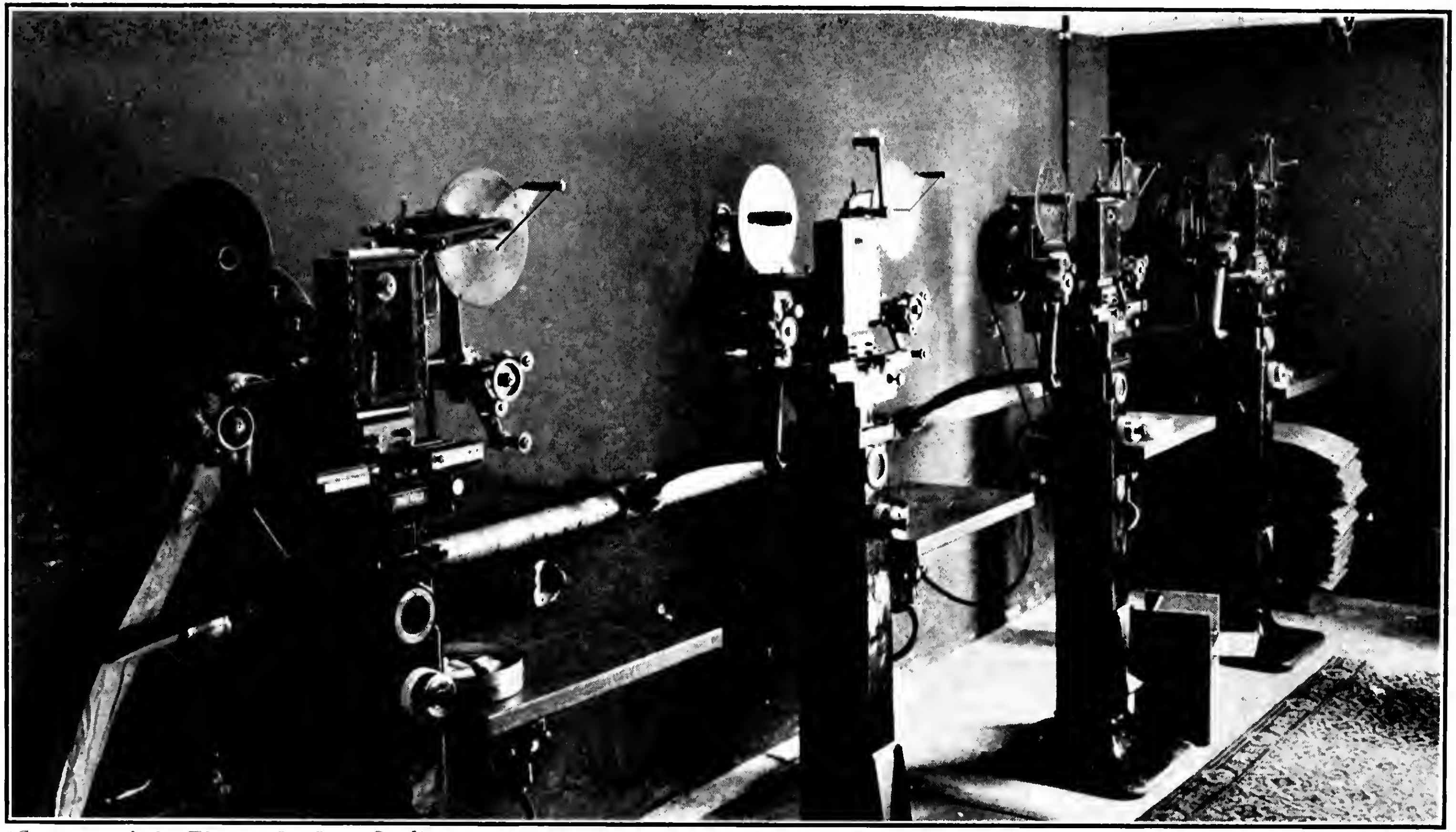
In the printer in question, one side of the light aperture is composed of a revolving segment whose movement is calibrated into twenty-two points and controlled by an index hand and dial mounted on the front of the machine. By placing the hand on point No. 1, the aperture is set for the smallest opening or an exposure by a strip of light 1/8 inch wide reaching across the film. Each consecutive point from No. 1 up, gives a ten per cent increase in exposure over the preceding one, consequently the wide latitude available for negatives of varying densities that this arrangement permits is very apparent. After setting the index hand at the desired light intensity (previously ascertained by consulting the original test pieces made of each scene), the actual change of aperture opening is automatically affected by means of a radial notch in the margin of the film between scenes allowing an electrical circuit to be completed which in turn shifts the movable element of the aperture to the desired position.

The light changes are accompanied by an audible signal incorporated in the mechanism, thus permitting the operator to properly follow the various scene changes listed on a card and placed on the machine for this purpose.

The advantage covered by the fourth clause referring to speed of operations, is maintained by constructing and adjusting the different controls that each can properly perform its duty at a rate of speed of approximately one foot per second of printed positive film or for an average eight-hour day with due allowance for changes, rethreading and other adjustments, twenty-two thousand feet, which is the normal rate of speed and in no way exceptional.

The operation of the machine is controlled by a combination switch handle and valve whose movement is limited to ¼ of a revolution and in making development tests it is easy to start and stop the machine quickly enough to allow of only a few images to be printed of each scene.

The air compressor is supplied in two sizes, the smaller being built to accommodate from one to three machines and the larger from one to twelve machines. The compressors supply a constant stream of air which is filtered through a silk bag mounted on a metal frame and attached directly to the intake pipe. The machines now being furnished require no auxiliary electrical equipment, all local circuits being operated from one source of supply.



*(Courtesy of the Thomas H. Ince Studios)*

PERFORATING ROOM SHOWING BELL AND HOWELL PERFORATORS.

## Chapter XI

# TINTING AND TONING MOTION PICTURE FILMS

Based on the methods worked out by the Eastman Kodak Research Laboratories

MANY practical methods have been worked out from time to time for the toning of lantern slides and photographic papers. When these are applied to the toning of motion picture film, the toned film obtained in most cases although apparently satisfactory when viewed in the hand, appears substantially black on projection. Generally speaking, the color of the image as seen in the hand is no criterion whatever of its appearance on the screen, so that in judging any particular tone it is essential to view the projected image.

The importance of producing toned images of the maximum degree of transparency is therefore at once apparent. The excellence of any formula may be estimated by its capacity for producing a transparent image which on projection shall retain the necessary vigor and snap.

While other methods have been suggested for producing a colored image, the method almost universally employed is to replace the silver by a colored metallic compound—usually a ferrocyanide of a metal of which,

Iron (ferric) ferrocyanide is blue
Copper ferrocyanide is red
Uranium ferrocyanide is reddish brown
Vanadium ferrocyanide is greenish yellow.
Silver Sulphide ferrocyanide is warm brown.

The object in toning is to replace the metallic silver composing the image by one of the above compounds, or by a mixture of the same whereby intermediate tones are obtained. This toning may be effected either by a two-solution process or by a single-solution process.

The two-solution process consists of first converting the silver image into silver ferrocyanide by means of a suitable bleaching bath, thoroughly washing and acting upon the ferrocyanide image with a metallic salt, usually in presence of an acid. Thus the metallic ferrocyanide is produced by double decomposition. The reaction, however, is never complete, so that the image is mixed with undecomposed silver ferrocyanide which tends to add "body" to the latter. If allowance is made in the original positive for this intensification, good tones are obtained.

Single-solution process: Instead of the two separate baths used above, a single solution may be employed consisting usually of the metallic ferrocyanide dissolved in a suitable solvent (say an alkali salt of citric, tartaric, or oxalic acids) in presence of an acid and certain other salts.

On immersion of the positive film in this solution the silver image is converted to silver ferrocyanide, whilst the colored ferrocyanide is formed simultaneously and in its proper place.

In view of the fact that the metallic ferrocyanide is deposited in a colloidal condition in presence of the gelatine of the film, its state of division, and therefore the nature of the tone, is usually affected by the presence of certain salts, changes of temperature, concentration of the baths and other factors which must be maintained constant in order to produce uniform results. With such single baths it is possible to secure tones which are unobtainable by a two-solution process. As these single solutions are sensitive to light and rapidly attack foreign metals, such as faucets, they are comparatively unstable and require care in their use.

Two-solution methods are reliable, economical, and are not so prone to influence of disturbing factors. The total time required for toning, however, is invariably double that taken up by a single-solution process, so that, from an economic standpoint, two-solution methods are especially recommended for the worker who tones occasionally.

In the above case if the toned image be treated with acid hypo to remove the opaque silver ferrocyanide, an almost pure colored image remains. The intensity of the toned image is, however, considerably diminished and, previous to toning due allowance must be made in choosing the positive in order that the final image shall be of the correct density for projection.

Since most toning processes either intensify or reduce the original image, it is most important to commence toning with positive film of the correct density, so as to obtain uniform results.

Any good metol-hydroquinone formula will produce good tones, although a straight hydroquinone developer will produce excellent tones in all cases except with certain vanadium and iron formulas for green tones. A metol-hydroquinone developer is essential in these cases in order that the rich olive-green color may be obtained, and the proportion of metol in the developer should be about twice the usual quantity.

Before toning it is necessary that the developed film should be entirely free from fog, since a thin veil becomes intensified in most of the toning processes. Fog may be caused by:

(a) Oxidization of the developer, noticeable by the brown coloration produced after continued use. The remedy is obvious. Do not use exhausted or badly oxidized developer.

(b) Carelessness in compounding the developer. The usual mistake consists in adding the carbonate to the metol and hydroquinone without previously adding some sulphite in order to prevent oxidation. It is not advisable, however, to add the whole of the sulphite to the metol and hydroquinone in the first place, otherwise the metol may precipitate.

(c) The presence of metals such as copper, brass and tin, and fumes from sodium sulphide, etc., in the developing baths are to be strictly avoided. A salt of copper if present only to the extent of one part in 10,000 will produce fog immediately on cine positive film.

It is advisable that all metallic parts such as pins on developing racks, etc., should be enamelled or replaced with hard rubber, or silver plated, in order to eliminate any source of danger.

Exposure and development are of great importance. In such a case as sulphide or copper toning, the best results can be obtained only on full development.

Fixing should be complete and, if possible, carried out in two consecutive baths followed by thorough washing, otherwise uneven coloring will result.

The toned deposits obtained by the processes recommended are as transparent as is consistent with "pluckiness," and only those formulae have been recommended which by virtue of their rapidity of action, long life, and cheapness, can be employed commercially.

Permanency of the tone produced in every case depends largely on the thoroughness and care exercised during the various chemical operations.

The silver sulphide image may be considered permanent, and likewise the blue tones in those cases where the film is finally fixed after toning. In the other cases, however, where more or less silver ferrocyanide still remains in the toned image, the film is not absolutely permanent (blue and green tones being affected by excessive heat). In no case, where instructions are carefully followed, will the toned image deteriorate during the active life of the film. Moreover, so far as can be ascertained, the wear and tear of film which has been toned by the methods recommended is in no way impaired. By virtue of the hardening action of most of the toning baths on the gelatine it is advisable, especially during the winter months, to immerse the film for three or four minutes in the usual 3 per cent. glycerine bath after toning.

In case film has to be stored for long periods of time it is inadvisable to tone the same, nor is it advisable to tone valuable film unless duplicates of the same are available.

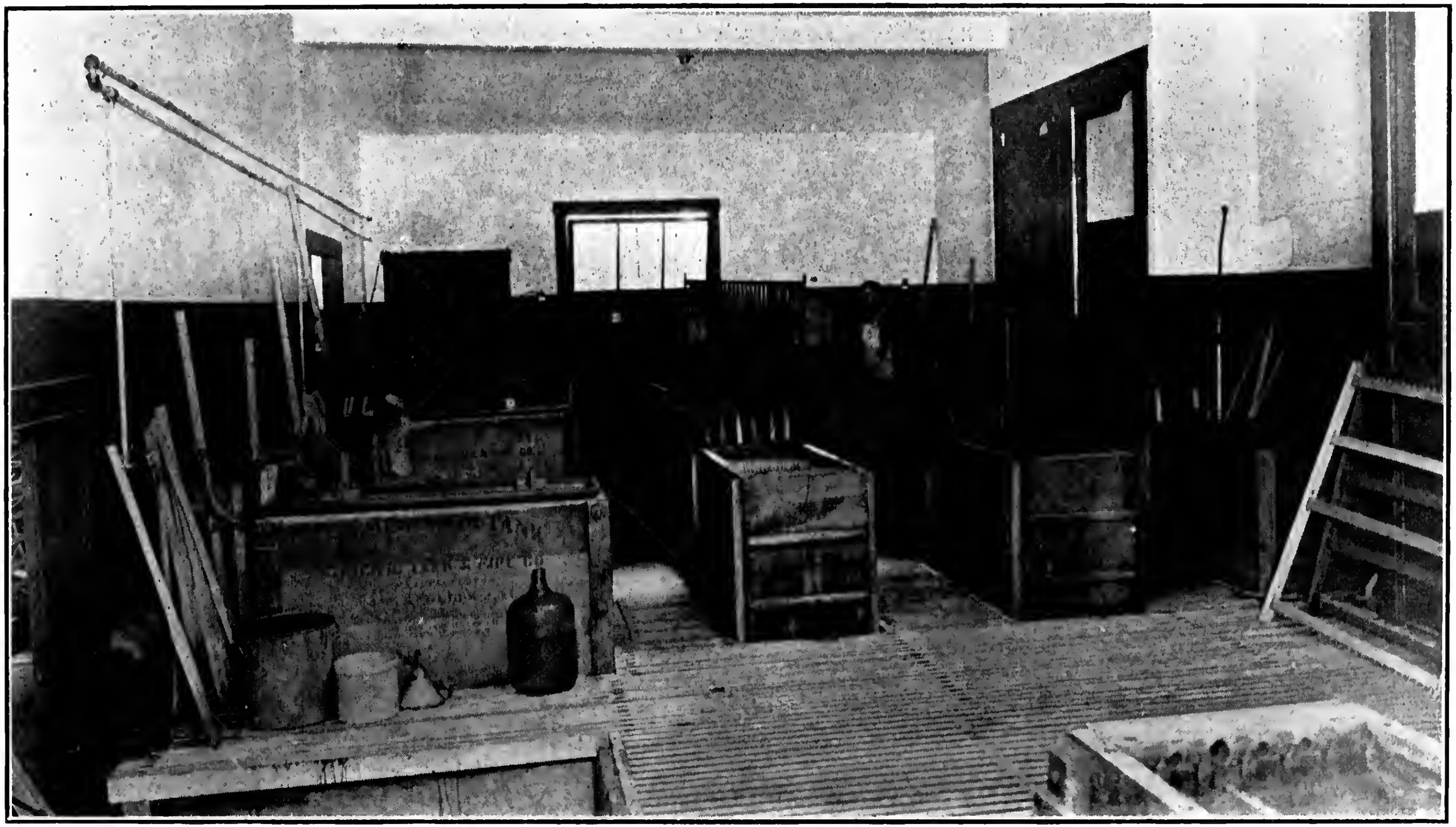
The life of the toning bath has been carefully investigated in each case. The term "life" is considered as the total length of film capable of being toned by a given volume of fresh solution when toning is conducted continuously and without interruption.

In all cases it is false economy to exhaust a toning bath to the limit and thereby obtain inferior tones. The cost of the chemicals employed is insignificant compared with the value of the film being treated, being about one per cent per twenty-five feet of film toned. (This calculation was made when chemicals were not so high as at present.)

The figures given represent the capacity of the baths for toning under the best conditions. They apply only providing the baths are kept covered to exclude light when not in use and providing no foreign metallic surface, however, small, is allowed to come into contact with the solution.

As previously mentioned, single-solution baths are not intended for use at very infrequent intervals. In such cases, two-solution methods should be employed, although it is possible only to recommend the latter for the production of green and blue-green tones.

Copper Red Tone. Red chalk color. Use a snappy, rather dark positive with this bath. After immersing the well-washed film in water for one minute, place in the following:



*(Courtesy of the Thomas H. Ince Studios)*

TINTING, TONING AND WASHING ROOM.

| | |
|---|---|
| Potassium Citrate | 6 lbs. 4 ozs. |
| Copper Sulphate | 1 lb. |
| Potassium Ferricyanide | 1 lb. |
| Ammonium Carbonate | 8 ozs. |
| Water to | 10 gals. |

Dissolve each ingredient separately in as little water as possible, mix the filtered solutions so obtained in the order given, and dilute to the required volume. The ammonium carbonate should be almost transparent, and free from white powder.

To obtain the best results the bath should be employed at 70° F. At higher temperatures inferior results are obtained and at 80° F. the bath is useless.

Tone for twenty to thirty minutes.

Washing should be continued until the high lights are perfectly clear, which usually requires from ten to fifteen minutes.

With use, the bath precipitates a brown sludge of copper ferrocyanide, and in consequence becomes weaker by virtue of the loss of copper. Ten gallons of the solution will tone about 1,000 feet of film without revival. As soon as the bath shows signs of weakness it should be revived by adding separately one-quarter the above amounts of copper sulphate, ferricyanide, and ammonium carbonate, dissolved in as little water as possible—omitting the potassium citrate.

The bath will not keep more than a few days even after being so revived. In view of the relative instability of this bath, it is more economical to employ a wooden drum immersed in a shallow tank (using fresh solution as soon as exhausted in place of the usual "tank and racks.")

Uranium Red Tone. Brownish red color.

Use a rather thin positive as this bath intensifies slightly. Immerse the well-washed film in the following:

| | *Avoirdupois* |
|---|---|
| Uranium Nitrate (Neutral) | 3 ozs. 150 Grs. |
| Potassium Oxalate (Neutral) | 3 ozs. 150 Grs. |
| Potassium Ferricyanide | 1 oz. 150 Grs. |
| Ammonium Alum | 8 ozs. |
| Hydrochloric Acid 10 per cent | 6 ozs. |
| Water to | 10 gals. |

Since the nature of the tone is influenced largely by the acid content, it is very important that the uranium nitrate should contain no free acid. This may be assured by neutralizing a solution of the same with dilute ammonia until a slight permanent precipitate is obtained.

It is most convenient to keep stock solutions of the above (say 10% solution) wherewith a new bath may be expeditiously compounded. A 10% hydrochloric acid solution is one containing 10 parts by volume of the acid per 100 volumes of the final solution.

Slight variations of temperature around 70° F. produce no apparent effect.

Tone for ten minutes. Since this and the following single solution methods of toning produce a marked intensification of the silver image—which intensification increases with the time of toning—it follows that the nature of the tone changes with the time.

The composition of the bath has been so adjusted that the maximum effect is produced in about 10 minutes, the tone passing through a series of changes from brown to red during this time.

Although it is possible to obtain intermediate tones by withdrawing the film from the bath at shorter intervals, the tones so obtained are not so "plucky," and it is almost impossible to duplicate them. Experience has shown that modifications of tone are best obtained by keeping the time of toning constant and varying the nature of the toning bath and that of the positive film employed.

Wash from ten to fifteen minutes.

Usually the high lights will become clear in the above time, although a thin yellowish brown veil invariably remains in the clear gelatine as a result of the intensification of minute traces of fog. This is of no account, however, in projection. If the bath is working correctly this yellowish veil is only just perceptible. Should it be at all marked, then either the film was fogged during development, or the bath was not compounded correctly. Washing should not be carried out for too long a period, especially with water inclined to be alkaline, because the toned image is soluble in alkali.

Ten gallons of solution will tone about 1,000 feet of film without any appreciable change in the tone, after which the rich tone tends to become flat as a result of a deficiency of acid in the bath. At this point the bath may be revived by the further addition of acid to the extent of the original amount employed, when a further 1,000 feet may be toned. After this stage the richness of tone falls off rapidly and the bath should be thrown away. In view of the sensitiveness of the bath to acid, the importance of the neutrality of the ingredients is at once apparent.

Used intermittently over a period of several days, the life of the bath is approximately the same.

With continued use a slight brownish flocculent precipitate may form in the bath, but this should be only slight, otherwise it is caused by incorrect mixing, the action of light, or by contact with a metallic surface.

Uranium Red Brown. Reddish Sepia Color. Use a positive that is a full shade lighter than a normal black and white. The formula employed is the same as for Uranium Red tone, but contains only half the amount of hydrochloric acid. The procedure is the same as that for Uranium Red Tone.

In view of the less energetic nature of this bath the life is slightly longer than that for Uranium Red. If after 1,000 feet of film have been toned the bath is renewed with acid to the extent of

6 ozs. ....................10% acid per 10 gals.

Then 10 gals. of solution will tone 3,000 feet of film.

Sepia Tone by Uranium and Iron. This particular tone is obtained by suitable admixture of red and blue toning solutions. By varying the proportions of these baths, tones from red sepia to brown may be obtained.

The following is only one of the many tones to be obtained by this method. Increase in the proportion of the iron baths makes the tone colder and vice versa.

Use a positive that is a full shade lighter than normal.

Immerse well-washed film in

Solution for Uranium Red Brown........ 9 vols.
Solution for Iron Blue.................. 1 vol.

The instructions regarding method of procedure, life of bath, etc., are exactly the same as for Uranium Red Brown.

Sulphide Yellow Brown for Tinting. This tone is seen to advantage only when subsequently tinted, as when used without tinting it gives a very unpleasing brindle brown.

Use a normal print for this tone as it reduces just about the correct amount for tinting.

| | | |
|---|---|---|
| A. | Potass. Ferricyanide .................... | 3 lbs. |
| | Potass. Bromide ...................... | 1 lb. |
| | Water to .............................. | 10 gals. |
| B. | Sodium Sulphide crystal................ | 3 oz. |
| | Hypo crystal .......................... | 8 oz. |
| | Water to .............................. | 10 gals. |

It is convenient to keep solutions of hypo and sodium sulphide (say 20%) and measure these out by volume as required. A trace of iron in the sodium sulphide is of no moment providing the stock solution is boiled and the precipitated iron sulphide allowed to settle before use.

The well-washed positive is thoroughly bleached in A, washed for five minutes, and immersed in solution B, until the film is thoroughly toned. This bath appears to "ripen" slightly with age so that a small amount of used bath should be added when compounding fresh solution or a waste piece of film should be toned in the new bath to secure the same effect.

The effect of temperature on the solution A is simply to hasten the bleaching. With bath B, on immersion of the bleached film two reactions occur:

(a) Solution of the silver bromide in hypo.

(b) Conversion of the silver bromide to silver sulphide.

Normally, good results are obtained at 70° F. Owing to the increased solvent power of hypo for silver bromide at high temperature, the tone becomes warmer and the image has less contrast at a limit of 75° F., beyond which it is inadvisable to go.

Hence, if the tone is too cold and the film too opaque, the temperature should be increased one or two degrees from 70° F. and vice versa.

Tone about five minutes and wash fifteen minutes.

The bleaching bath A will keep until exhausted. Ten gallons of bath B will tone about 2,000 feet of film, after which there is a tendency for a dichroic fog-like deposit to form on the surface of the film during toning owing to the hypo becoming saturated with silver bromide. As soon as this happens, the bath should be renewed.

Green tones by Vanadium and Iron. Use a normal black and white positive for this formula.

Tone in the bath prepared as follows:

| | | Avoirdupois |
|---|---|---|
| A. | Oxalic acid | 1 lb. 4 oz. |
| | Vanadium stock solution | 40 oz. |
| | Water to | 5 gals. |
| | | *Avoirdupois* |
| B. | Potass. ferricyanide | 3 ozs. 145 grains |
| | Water to | 20 gals. |
| C. | Ferric Alum (Ferric Ammonium Sulphate) | 8 oz. 145 grains |
| | Potass. Bichromate | 72 grains |
| | Oxalic acid | 7 oz. |
| | Potass. ferricyanide | 3 oz. |
| | Water to | 15 gals. |

Dissolve each of the chemicals separately and mix the solutions obtained strictly in the order given.

| | | Avoirdupois |
|---|---|---|
| D. | Ammonium Alum | 2 lb. 1 oz. 110 gr. |
| | Hydrochloric acid 10% | 13½ oz. |
| | Water to | 10 gals. |
| | Total Volume | 50 gals. |

Add B to A with stirring; then add C, and finally add D to the mixture. The solution is then ready for use.

The syrupy variety of Vanadium Chloride sold by Merck is recommended although its nature appears to vary with different batches, certain samples being very difficult to incorporate with the toning bath without giving rise to precipitation.

Vanadium Stock Solution:

| | Avoirdupois |
|---|---|
| Vanadium chloride (syrup) | 3½ fl. oz. |
| Oxalic acid | 3 oz. 200 gr. |
| Water to | ½ gal. |

Any sludge which may have been deposited from the vanadium chloride should be included also and the whole heated in a glass or enamelled vessel until a clear blue solution is obtained.

The method of mixing the various solutions A, B, C and D is of the greatest importance. They should be mixed only in the concentrations recommended and strictly in the order given. Unless this is done, the vanadium will precipitate out as a green sludge.

Variations of temperature around 70° F. have little or no effect.

Tone ten to fifteen minutes and wash for the same length of time. Washing should be thorough as it is only during washing that the rich green tone develops.

Ten gallons of solution will tone about 1,400 feet of film without any appreciable deterioration of tone, and if at this point, and after each 1,000 feet, the bath is revived by the addition of hydrochloric acid equivalent to the amount originally employed: i.e.

2⅔ ozs., 10% Hydrochloric Acid per 10 gals.

3,000 feet may be toned. As the bath becomes exhausted it may be found necessary to increase the time of toning to fifteen minutes. It is not permissible to add further amounts of vanadium chloride in order to revive the bath, as the vanadium would then be precipitated. The vanadium may be incorporated with the bath only at the time of mixing.

Used intermittently the life is approximately the same.

Greenish Blue Tone With Vanadium And Iron. Use normal black and white positive for the formula.

The formula employed and instructions are exactly the same as for Green tones by Vanadium and Iron, except that the proportion of Vanadium chloride is as follows:

Vanadium Chloride Stock Solution.
Per 10 gal. of bath, 4 ozs.

and only half the amount of hydrochloric acid should be employed. It is not permissible to convert this bath to the preceding by the addition of further amounts of vanadium chloride, in which case the latter would be precipitated.

Positives for this bath should be a full shade or even two shades lighter than normal and should be developed in metol-hydroquinone developer as a plain hydroquinone formula does not give good results with this bath.

| | | *Avoirdupois* |
|---|---|---|
| A. | Potassium Ferricyanide ......... | 4 lbs. 4½ ozs. |
| | Ammonia .880 .................. | 13 ozs. |
| | Water to ...................... | 10 gals. |

Bleach for two to ten minutes, then wash for ten or fifteen minutes, tone in the following:

| | |
|---|---|
| B. Ferric alum (crystal) | *Avoirdupois* |
| (Ferric ammonium sulphate).... | 13 ozs. 2 drams |
| Vanadium chloride (stock sol.)... | 25 fl. ozs. |
| Potassium bromide ............ | 6 ozs. 5 drams |
| Hydrochloric acid (concentrated). | 2½ ozs. |
| Water to .................... | 10 gals. |

Refer to green tones by Vanadium and Iron for composition of vanadium stock solution.

Temperature of toning should be around 70° F. and the time of toning ten to fifteen minutes.

Wash for ten minutes after toning.

Providing bath A is screened from the light and kept covered in order to prevent the undue escape of ammonia, the bath keeps fairly well. Should it show any signs of weakening it should be revived by the addition of a further quantity of ammonia equal in amount to that originally used. If so revived at intervals, 10 gallons will bleach 8,000 feet of film before exhaustion.

Ten gallons of solution B will tone 6,000 feet of film without further addition of acid, after which it should be thrown away.

Olive green tones with iron (two solutions).

This tone is almost indistinguishable from those obtained with vanadium. Use a thin metol-hydroquinone developed positive with this formula, plain hydroquinone does not give very satisfactory results.

Bleach in solution A as for green tones by vanadium and iron, and after washing for ten to fifteen minutes tone in:

| | |
|---|---|
| | *Avoirdupois* |
| Ferric Alum .................. | 13 oz. 2 drams |
| Potassium bromide ............. | 6 oz. 5 drams |
| Hydrochloric acid (concentrated). | 2½ oz. |
| Water to .................... | 10 gals. |

The time of toning, washing, life of bath, etc., are the same as for green tone by Vanadium and Iron. Should the high lights of the toned image be stained blue, this is due to insufficient washing after bleaching:

Iron Blue Tone. Use normal or slightly thin positive. Tone in the following;

| | *Avoirdupois* |
|---|---|
| Potassium bichromate | 15 grains |
| Ferric Alum | 1 oz. 250 grs. |
| Oxalic acid | 4 oz. |
| Potassium ferricyanide | 1 oz. 146 grs. |
| Ammonium alum | 6 oz. 5 drams |
| Hydrochloric acid 10% | 1 oz. 2 drams |
| Water to | 10 gals. |

The method of compounding this bath is very important. Each of the solid chemicals should be dissolved separately in a small quantity of warm water and the solutions allowed to cool. Then the latter should be filtered into the tank strictly in the order given, and the whole diluted to the required volume. If these instructions are adhered to, the bath will be free from any sign of precipitate and will remain so for a considerable period.

Tone for ten to fifteen minutes and wash ten to fifteen minutes until the high lights are clear. A very slight permanent yellow coloration of the clear gelatine will usually occur, but should be only just perceptible. It is of no moment in projection. Should any sign of blue stain occur, it is an indication of a stale bath or incorrect mixing of the same. These remarks regarding stains apply in all cases where single toning solutions are employed.

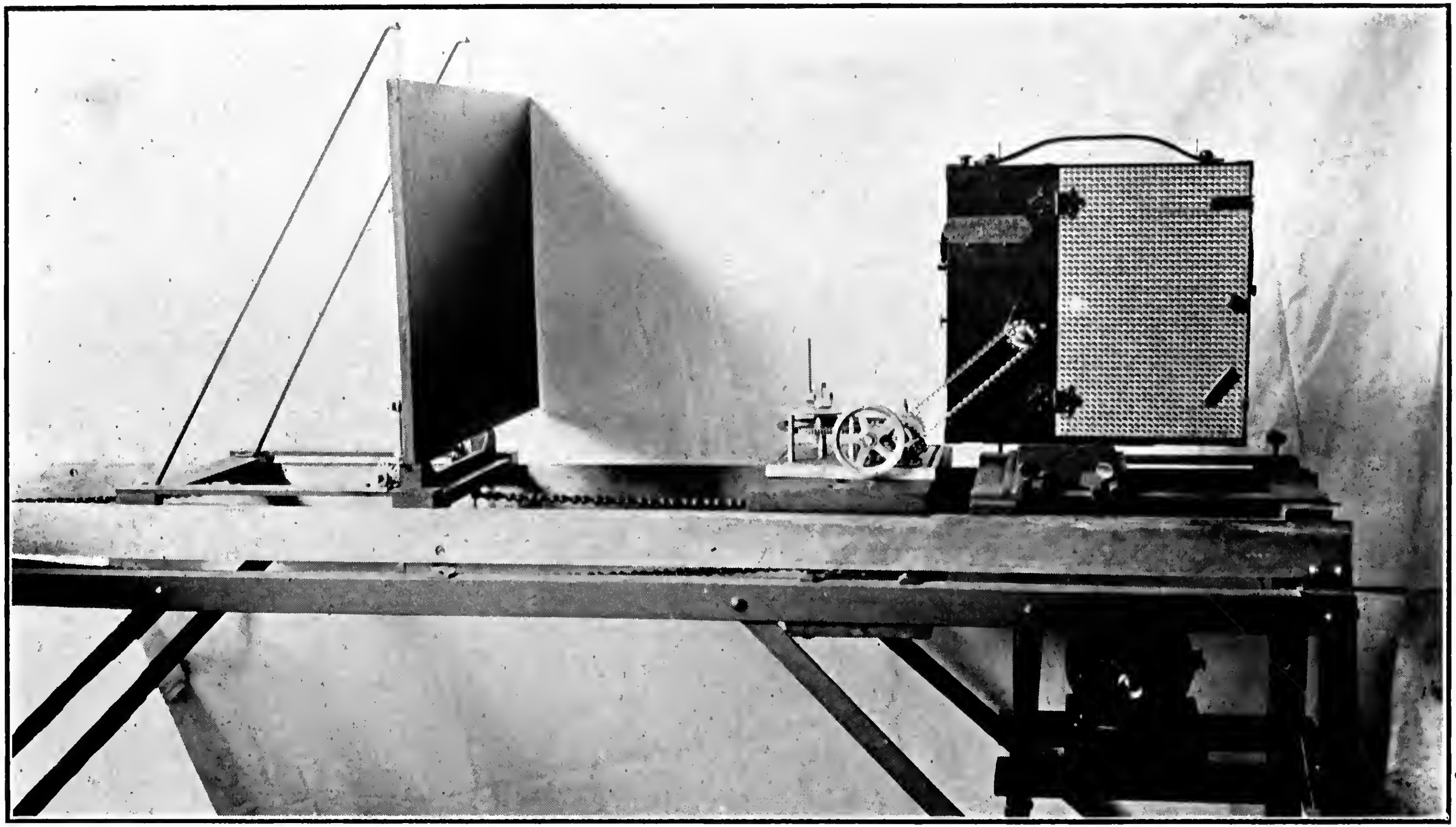
If the acid is replaced to the extent of the original amount after toning each 1,000 feet, the bath will on the whole tone 3,000 feet per ten gallons of solution.

If even after revival, the tone remains flat, the bath is exhausted and should be thrown away. As the bath becomes exhausted, the time of toning should be extended a little longer than ten minutes in order to obtain the necessary contrast.

After continued use, a slight bluish sludge will collect in the bath, but this is of no moment. Should this form, however, to an appreciable extent, it is due either to incorrect mixing, the action of light, or to contact with metallic surfaces.

Two-Solution Iron Blue Toning Bath. Starting with a light, normal positive, this is toned according to instructions given for olive-green tones with iron.

The tone image is then immersed in the following fixing bath for three minutes;



*(Courtesy of Rinaldy Machine Company)*

RINALDY ADJUSTABLE TITLE BOARD.

| | |
|---|---|
| Hypo (crystal) | 8 lbs. 5 ozs. |
| Sodium bisulphite (EKCo) | 2 lbs. 1¼ ozs. |
| Water to | 10 gals. |

After fixing, the film is washed for ten to fifteen minutes. If the resultant image is too thin, the toning solution should be allowed to act for fifteen minutes, or positive film of greater contrast should be employed.

Violet Tone With Iron and Ammonia. Iron blue tones may be converted to violet or dark blue by immersion for one to two minutes in the following bath.

| | *Avoirdupois* |
|---|---|
| Ammonia Pure .880 | 3 to 5 ozs. |
| Water to | 10 gals. |

Wash for one or two minutes and dry.

After some time the film will turn blue again but the violet tone can be restored by treatment with ammonia.

In many cases pleasing effects may be obtained by tinting film which has already been toned. The result is that the clear portions of high lights assume the color of the dye, whilst the shadows and half-tones project a tint intermediate between that of the dye and the toned deposit.

Considerable judgment is necessary in choosing suitable tints to blend with any given tone.

The most successful combination of toning with tinting is in the production of sunset and moonlight effects over water. First tone blue and subsequently tint "orange" or "red."

The following combinations will cover most cases required:

Yellow Brown tone with pink tint.

Green and Blue tones with light yellow tint.

Blue and Violet with almost any delicate shade.

It is considered unnecessary to illustrate every combination of tone and tint. Only typical examples have been given. It must be noted that toned film except copper and sulphide toned, dyes more quickly than untoned film in any given dye bath. In order to obtain the exact tints above, the dye bath should be diluted with about an equal quantity of water.

Dye for five to ten minutes, according to shade desired.

The equipment necessary for systematic toning and tinting is essentially the same as that required for development, consisting of the usual tanks and racks or small drums. It is highly desirable to use the same for this purpose exclusively and if possible keep in a separate room thus excluding any possibility of contamination either by the copper or sulphiding bath, which would cause development fog immediately.

The "drum" system, on account of the great expense involved in apparatus and the larger space required for manipulation, is not to be recommended for toning and tinting operations. For the worker on a small scale, who desires only to produce short lengths of film occasionally, a small wooden drum revolving in a shallow wooden tank is most efficient and economical. The tanks employed should be of slate or other resistive materials, and have in an outlet at the bottom a hard-rubber stopcock or a wooden plug.

Wooden tanks may be used but when once used for one color cannot be used for any complementary color.

The tank containing the sulphiding bath should be enclosed in an outer tank through which hot or cold water may be circulated in order to control the temperature. The racks or drums may be of wood, but if metal pegs are employed they should be coated with an acid-resisting paint such as asphalt. The presence of any metalic surface in the toning baths will cause contamination of the same and effect a precipitation of sludge. Neither toning nor tinting frames should be interchanged but should be kept separate in order to prevent contamination of one bath by frames employed in another. This also applies to the small drum system. A pink tint would be ruined by using a rack which had been immersed in a deep blue dye bath unless the rack had been washed thoroughly.

In the case of delicate tinting, however, no harm is done providing the racks have been coated with the following waterproof varnish:

| | *Avoirdupois* |
|---|---|
| Hard Paraffin | 1 lb. 5 ozs. |
| Syrian asphalt | 1 lb. 5 ozs. |
| Benzol | 4 gals. |
| Carbon tetrachloride | 3 gals. |

Before varnishing it is preferable to immerse the racks in a 1% solution of hydrochloric acid for two or three minutes and wash for fifteen minutes. Dry thoroughly. Then dip the well-dried racks in the above solution and drain off the excess liquid. The varnish dries almost immediately.

The varnishing should be repeated at intervals.

Developers, toning solutions and dyes should be mixed in crocks of glazed earthenware. Use warm water when possible and ensure thorough solution by stirring with a wooden paddle, which should be thoroughly washed after each operation. Having dissolved the chemicals in as small a quantity of hot water as possible, the solution should be cooled so that on dilution the final solution will be at approximately the correct temperature.

The chemicals employed should be pure. When a good water supply is not available, distilled water only should be employed.

In "tinting" the following factors must be taken into consideration:

Dyestuffs are chemically of two different types, acid and basic; so-called acid dyestuffs are the alkali—usually sodium salts of organic acids—whilst basic dyestuffs are the chlorides, sulphates, etc., of organic bases.

For the tinting of film only "acid" dyestuffs should be considered, since "basic" dyestuffs usually enter the gelatine so rapidly that satisfactory control of the dyeing is impossible. Moreover, it is not possible to make a complete selection from basic dyestuffs alone. Such a selection would necessitate the use of acid and basic dyestuffs in admixture—a procedure highly undesirable and, in many cases, impossible.

Any dyestuffs suitable for admixture to produce intermediate tints should possess the following properties:

The dye should be inert and not attack the gelatine or support. This is of fundamental importance as the gelatine coating of dyed film in many cases has a tendency to lose its flexibility, causing what is known in the trade as "brittleness."

Several dyestuffs when employed at a concentration of 1%, attack gelatine readily at 70° F. and vigorously at 80° F., especially in presence of small amounts of acids, producing a marked softening and often partial solution of the film. The effect is roughly proportionate to the concentration of the dye and to the temperature, and varies with each individual dyestuff. Experience shows that the gelatine coating of film which has been softened in this way by the dyestuffs becomes "brittle" on subsequent projection.

The actual factors in the production of brittleness are:

1. The hydrolysis of the acid which, in many cases, is added to assist dyeing. If a solid acid has been employed the heat encountered during projection will greatly accelerate this hydrolysis.

2. The corrosion of the dye itself. Dyes vary considerably in this respect according to their particular composition. So far, it has not been possible to make any general classification of dyestuffs in this connection, though nitro compounds appear to be particularly corrosive in their action.

3. The presence of impurities in the dyestuff. These take the form of excessive amounts of loading material, such as sodium sulphate or chloride, or small traces of iron, the latter having a tendency to harden the film considerably.

In all the above cases, the nature of the gelatine is altered. It loses its property of remaining resilient under normal conditions of temperature and humidity and becomes "brittle."

A suitable test as to whether a dyestuff has any propensity to produce brittleness is to incubate a sample of film, half of which has been dyed, for about 48 hours at 100° degrees C. If any difference in brittleness is noticeable between the dyed and undyed portions so treated, the dye is unsuitable for tinting.

On the contrary most dyestuffs, when used at a concentration of 1% and at 80° F., produce more or less softening of the gelatine. This may be prevented by:

(a) Use of dilute solutions only. Except in special cases, a dye solution stronger than 0.5% is seldom required. The usual strength employed is about 0.2%, at which concentration no softening usually occurs.

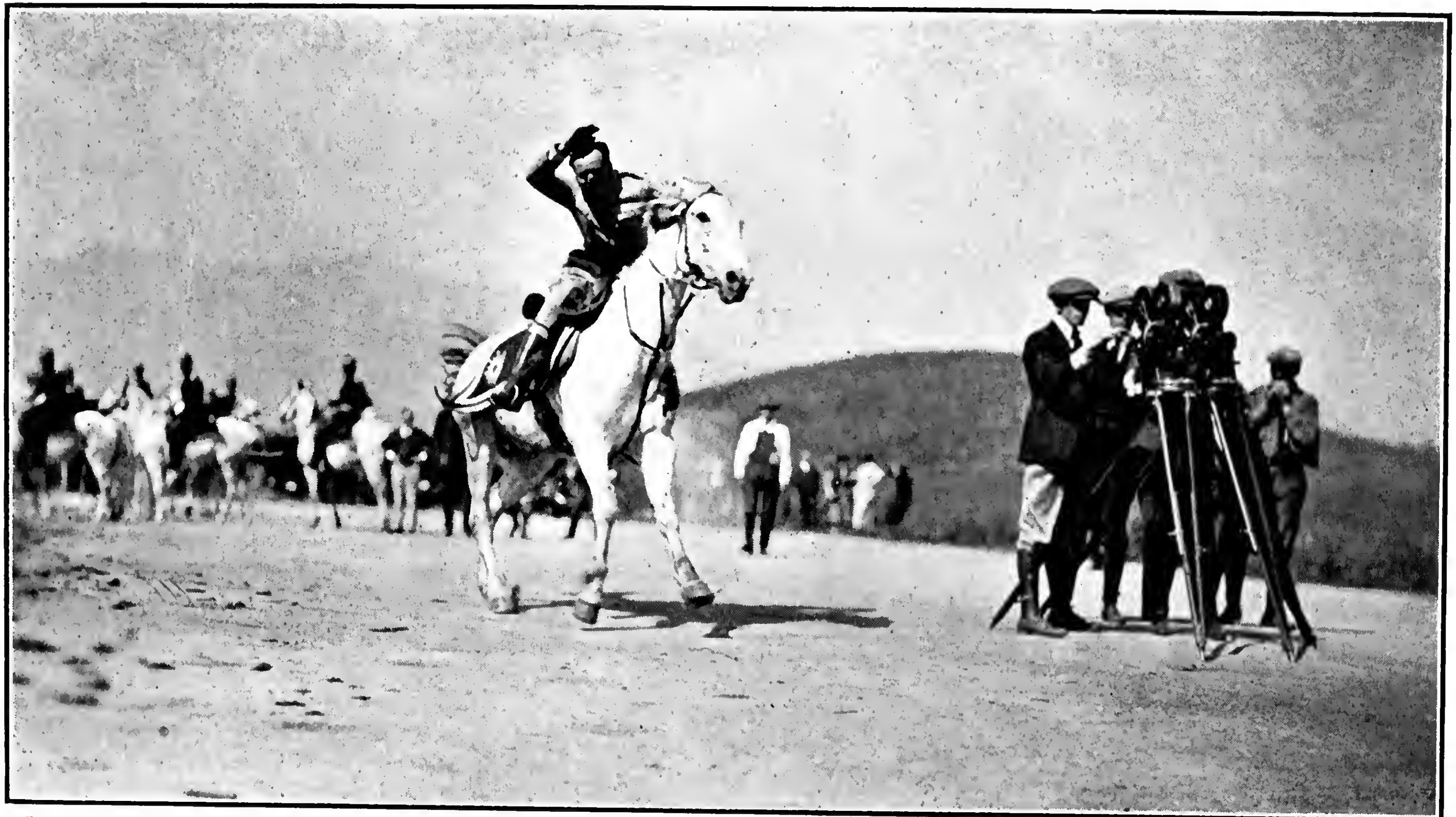
(b) Omission of acid from the dye bath.

(c) By working at temperatures not higher than 70° F.

(d) By slight hardening of the film before dyeing and subsequent softening by glycerine, as described below:

The dye should not "bleed" to any considerable extent when the film is washed; in other words, the rate of removal of the dye should be slow and be almost imperceptible in a period of say, five minutes.

Generally speaking, basic dyestuffs which are absorbed readily by gelatine do not bleed whilst most acid dyestuffs which dye gelatine much more slowly bleed considerably. The rate of bleeding appears to vary inversely as the affinity between the dye and the gelatine.



*(Courtesy of Douglas Fairbanks Film Company)*

DOUGLAS FAIRBANKS ABOUT TO SPEED PAST THE CAMERAS.

In tinting, bleeding is of considerable importance.

During the period between rinsing after dyeing and the placing of the film on the drying rack, any drops of water on the surface of the film become more or less saturated with dye. These, after drying, remain as spots and irregular markings which are very apparent on the screen.

It is possible only in very few cases to modify this bleeding by an acid "stop bath," and it may be considered a general rule that the bleeding of a dyestuff is a property peculiar to itself. In making a selection of dyes therefore, it is necessary to choose only those which have a minimum propensity to bleed.

The rate of dyeing should be only slightly affected by the addition of acid to the dye bath.

In some instances it has been recommended to add a small amount of acid to the dye bath to obtain more transparent results and to increase the rate of dyeing, but we do not recommend the use of acid for the following reasons:

(a) Acid magnifies the effect of temperature both on the rate of dyeing and on the softening of the gelatine.

(b) Acidified dye baths usually dye too quickly and often produce uneven dyeing around the perforations. Moreover, in many cases the degree of dyeing is very sensitive to changes in acidity. Since the acidity of the bath falls off with use, just as in toning, it is almost impossible to duplicate results systematically.

If acid is used it should be a volatile acid such as acetic acid, as any solid acid is retained in the film after dyeing. In all cases the effect varies with the particular dyestuff employed, and may be considerable even when the acid (acetic) is present only to the extent of .02%.

The dyes should be stable to light and not be "dichroic" or change color on dilution.

Moreover, the wear and tear of the film should not be impaired in any way after dyeing. Even after incubating for 48 hours at 100° C., no difference should be discernible between dyed and undyed films.

The dyestuff should not be affected by "hypo" since any fixing solution left in the film, or accidentally splashed thereon, would destroy the dye immediately.

Examination shows that most dyes fail on the "bleeding" test, whilst others, which might otherwise appear entirely suitable, attack the gelatine at higher temperatures or cause "brittleness."

In view of the large number of tints required in commercial work, it is undesirable to keep a separate dye-powder for the preparation of each particular bath. Prepare the same by admixture of three or more dyestuffs. If three only are employed, mixing must be conducted with great precision in order to reproduce any given tint. This difficulty is overcome by the use of intermediate colors.

The following five standard dyes have been chosen as fulfilling the above conditions as nearly as possible. By suitably mixing solutions of these as indicated in the specimen chart, almost any desired tint may be obtained:

| *Name used in Formula* | *Commercial Name* | *Manufacturer* |
|---|---|---|
| Cine Red | Chromotrop FB | Hoechst |
| Cine Orange | Orange GRX | Badische |
| Cine Yellow | Quinoline Yellow | Badische (Hoechst, Agfa.) |
| Cine Blue-Green | Brilliant Patent Blue | Hoechst |
| Cine Blue | Naphthaline Blue 12B | Hoechst Kalle |

ABBREVIATIONS

Hoechst is Farbwerke Hoechst Co., 122 Hudson St., New York City.

Badische, Badische Co., 128 Duane St., New York City.

Agfa, Berlin Anilin Works, 213-215 Water St., New York City.

Kalle, Kalle and Co., 530 Canal St., New York City.

These dyes are the commercial grades as supplied by the various dye makers. As a rule, they contain about 20% of loading material in the form of sodium chloride or sodium sulphate which in no way injures the film.

The relative cost of pure dyestuffs compared with commercial samples prohibits their employment commercially.

The amount of impurity in the dyes may vary slightly from batch to batch. This variation is usually so small as not to affect materially the nature of the tint obtained from any particular formula. Moreover, dye samples of the same name supplied by different makers may differ considerably in their properties, particularly with respect to "bleeding."

All tints we have described were obtained with dye samples from the makers indicated. Should dyes of other makers be employed, the proportions stated may require slight modifications Match any given color under artificial light only.

| *Tint No.* | *Formulae for Tinting* | *Avoirdupois* |
|---|---|---|
| 1. | Cine Red | 2 lbs. |
| | Water | 50 gals. |
| 2. | Cine Red | 8 oz. 145 grains |
| | Cine Yellow | 8 oz. 145 grains |
| | Water | 50 gals. |
| 3. | Cine Red | 5 oz. 220 grains |
| | Cine Yellow | 5 oz. 220 grains |
| | Water | 50 gals. |
| 4. | Cine Red | 3 oz. 350 grains |
| | Cine Yellow | 3 oz. 350 grains |
| | Cine Blue-green | 320 grains |
| | Water | 50 gals. |
| 5. | Cine Red | 5 oz. 260 grains |
| | Cine Orange | 1 lb. 11 oz. 175 grains |
| | Water | 50 gals. |
| 6. | Cine Red | 1 oz. 175 grains |
| | Cine Orange | 6 oz. 350 grains |
| | Water | 50 gals. |
| 7. | Cine Orange | 11 oz. 45 grains |
| | Water | 50 gals. |
| 8. | Cine Orange | 16 oz. 300 grains |
| | Cine Yellow | 16 oz. 300 grains |
| | Water | 50 gals. |
| 9. | Cine Orange | 4 oz. 75 grains |
| | Cine Yellow | 4 oz. 75 grains |
| | Water | 50 gals. |
| 10. | Cine Yellow | 2 lbs. |
| | Water | 50 gals. |
| 11. | Cine Yellow | 8 oz. |
| | Water | 50 gals. |
| 12. | Cine Yellow | 1 lb. 4 oz. |
| | Cine Blue-green | 2 oz. |
| | Water | 50 gals. |
| 13. | Cine Yellow | 14 oz. |
| | Cine Blue-green | 2 oz. 350 grains |

| *Tint No.* | *Formulae for Tinting* | *Avoirdupois* |
|---|---|---|
| | Water | 50 gals. |
| 14. | Cine Yellow | 7 oz. |
| | Cine Blue-green | 1 oz. 175 grains |
| | Water | 50 gals. |
| 15. | Cine Yellow | 9 oz. 130 grains |
| | Cine Blue-green | 7 oz. 175 grains |
| | Water | 50 gals. |
| 16. | Cine Blue-green | 1 lb. |
| | Water | 50 gals. |
| 17. | Cine Blue-green | 4 oz. |
| | Water | 50 gals. |
| 18. | Cine Red | 250 grains |
| | Cine Blue-green | 12 oz. 30 grains |
| | Water | 50 gals. |
| 19. | Cine Blue | 4 oz. |
| | Water | 50 gals. |
| 20. | Cine Red | 6 oz. 145 grains |
| | Cine Blue-green | 4 oz. 350 grains |
| | Water | 50 gals. |
| 21. | Cine Red | 3 oz. 85 grains |
| | Cine Blue-green | 2 oz. 175 grains |
| | Water | 50 gals. |
| 22. | Cine Red | 5 oz. 175 grains |
| | Cine Blue-green | 1 oz. 260 grains |
| | Cine Yellow | 1 oz. 150 grains |
| | Water | 50 gals. |
| 23. | Cine Red | 3 oz. 90 grains |
| | Cine Yellow | 380 grains |
| | Cine Blue-green | 1 oz. 30 grains |
| | Water | 50 gals. |
| 24. | Cine Red | 10 oz. |
| | Cine Blue | 1 oz. |
| | Water | 50 gals. |

The solid dyestuffs are thoroughly dissolved in as small an amount of hot water as possible and filtered through fine muslin. Hot water should be poured over any residue, which should be slight, in order to ensure thorough solution of the dye. Then the dye solution should be diluted in the tank to the required volume at 70° F.

*(Photo by U. S. Signal Corps)*

EXAMINING FILM—SIGNAL CORPS SCHOOL OF PHOTOGRAPHY AT COLUMBIA UNIVERSITY.

Except in special cases, such as fire scenes, sunset and moonlight effects, it is very undesirable to employ strong tints. Apart from the displeasing effect and irritation to the eye, the dyestuffs produce a slight softening of the gelatine film when used at 80° F. in 1% solution.

Should it be necessary to employ such concentrated baths in summer, it is necessary either to cool the dye bath or use a suitable hardener. No trouble will be encountered if formalin (40%) be added to the dye bath to the extent of 1 volume to 400 volumes of dye solution. This is unnecessary if hardener was employed in the fixing bath after development.

During the winter months it is advisable to treat all film after developing and fixing with glycerine. The latter may be incorporated with the dye bath thereby eliminating an extra operation. The strength of the glycerine should be 2%, or two volumes per one hundred volumes of dye solution. However, in most cases the addition of glycerine considerably retards the rate of dyeing. Therefore, in order to obtain the same degree of tinting within a period of ten minutes the concentration of the dye bath should be increased accordingly.

The use of delicate tints both removes the contrasting black and white effect and adds a touch of warmth to the black deposit of silver, even in cases where the high lights are insufficiently stained to be noticeable. In many cases the result is equal to that obtained by partial toning.

Although temperature has little effect on the rate of dyeing with the dyes recommended, it is advisable in all cases to work at 70° F. in order to produce uniform results and avoid any danger of softening the film.

Only good "plucky" positive film may be successfully tinted. As tinting tends to reduce contrasts, the positive should be of normal density but slightly on the hard side.

Time of dyeing depends somewhat on the previous handling of the film. Film which has been fixed in a bath containing ordinary, or chrome, alum dyes more quickly than that treated with plain hypo and hardened with formalin. It is probable, therefore, that small traces of alum are left in the film even after prolonged washing. The alum serves as a mordant for the dye.

The film for dyeing should be fixed in hypo containing sodium bisulphite only (25% hypo with 2.5% sodium bisulphite—the cooled bisulphite being added to the cooled hypo). In case an alum fixing bath is employed or if, for any other reason, the tints indicated are not obtained in the time given below, either the time of dyeing or the dilution of the dye bath must be altered.

The concentration of the dye bath has in each case been so adjusted that dyeing is complete in ten minutes—which time is considered a minimum for the production of uniform results, and for complete control of the dyeing operations. Shorter time of immersion will produce lighter tints. As is the case of toning, experience has shown that in order to produce uniform results it is advisable to keep the time of dyeing constant, and obtain varying effects by changing the composition of the dye baths.

Should the film for any reason be over-dyed, a small portion of the dye may be removed by washing from 10 to 15 minutes, though the particular fastness of the dyes allows only slight mistakes to be rectified in this manner.

Life of the dye bath averages about 40,000 feet per 50 gallons dye bath. The bath may be revived at intervals by the addition of more dye, though this procedure is uncertain. It is generally advisable to mix fresh solution.

Either the "drum" or "tank" method may be employed. In either case after dyeing for ten minutes (during which time the rack should be agitated in order to ensure even dyeing and prevent accumulation of air bubbles) the film should be given a thorough rinsing in plain water.

Before drying film on racks it is advisable to set the rack at a slight angle for a few minutes, so enabling the surplus water to drain off through the perforations. If drums are used for drying it is advisable to remove the surplus water by whirling the drum previous to drying.

Patchy and streaked film results from insufficient washing of the positive after fixing and before dyeing, insufficient agitation of the rack when in the dye bath, and the use of dyes which "bleed" too freely.

In general, almost any tint, if delicate, may be employed with advantage. For general use those ranging through pink, rose, orange, yellow, pale green and pale blue, are recommended—others are for special purposes. The nature of the tint as seen in the hands is no criterion of its appearance on the projected image, though by a little practice and by viewing only by artificial light, it is possible to preconceive the appearance of any sample on projection.

## Chapter XII

# CUTTING AND EDITING

WITH the gratifying general progress of events toward a higher standard in motion picture art comes the necessity for scrcpulous and painstaking care in every detail and department of production and finishing. Methods that were the result of a naive scramble for wealth in an "easy money" market are obsolete. The old timers are almost relegated to the background. The old order is fast changing, giving place to new methods, new systems and new men. And in the great struggle for the survival of the fittest success depends upon the perfection of every detail.

It is gratifying to note that titling, that most important detail in the making of a picture, is receiving more and more attention from producers. They realize that more effectiveness as well as considerable saving in expensive crowds and settings can be gained by collaboration with a titler who is an expert literary craftsman.

One of the first indications of an awakening consciousness of the value of titles was seen in the mechanical end of their making. A more elaborate style of letter was introduced and later this was elaborated by the introduction of silhouettes or allegorical figures. Rarely indeed, were these good, in many instances they were laughable. Nevertheless they were welcome, for they were indications of improvement. This pseudo-artistic decorative work had a long run and is still in vogue to a considerable extent. It has not the qualities to make it a joy forever; folk tire of it. Gradually it must meet the exactions of art.

A more important question is: How improve the literary value of the writing of the titles? Here is a field as wide as the industry itself. The old-style running commentary on the picture, with its crudities, barn-storming heroics, cheap platitudes and abortive attempts at fine phrasing, is doomed. It cannot withstand the ever-increasing pressure of an elevating competition. Those who write these titles must either mend their ways or find other occupation in keeping with their limitations.

In the pictures of certain producers a great advancement in titling may be noted. These concerns apparently take a wider view of their mission in life than merely to earn dividends. As soon as a producer's aspirations are limited by the boundary line of "profits," the quality and grade of his work suffers. He tries to "get by" with cheap effects—including inferior titling—and immediately the discerning eye can read the writing on the wall.

Titles, to stand the test, must set forth the very spirit of the play—they must fill the blank that invariably exists between picturization and drama. The most intelligent audience would fail to get the significance of an author's intention without titling. Upon it largely depends the success of the picture. That being the case, why not insist upon good titles?

Good titles should be felt rather than seen. That is to say the subconscious appeal of the words should be such that the audience actually lives the part with the actor and literally feels the emotions portrayed on the screen. This is worthy work for the word-artist. Further, the style of the title should be such that the words flow easily, there must be no jarring note nor discordance. The words must open the door into the mind of the audience with graceful and powerful tact.

Successful titling calls for highly specialized ability. It is a profession, one that by its very nature will never be overcrowded. The process of elimination is becoming more severe as the public becomes more educated and better able to appreciate the merit of a picture and its accessories. Adequately to convey a world of sentiment, pathos or enthusiasm in a few short words, calls for skill. Many who attempt it never rise above the succinct phraseology of the "ad" man—their work is cold, staccato, and feelingless. The able title writer is worthily in a foremost place among those who make movies. In his hands lies the making or marring of a picture.

It has been argued that the public is no judge of the literary value of titles, and therefore anything readable will "get by." Nothing could be more inaccurate. If the public doesn't think, it feels. The unerring instinct of an audience invariably pays a tribute to good work, whether titling, or directing, or acting. All of these points must be carefully considered by producers who wish to turn out worth-while work; and they will be well advised to get the best obtainable in the brain-market to safeguard their titling.

(*Courtesy of the Thomas H. Ince Studios*)

NEGATIVE INSPECTION ROOM.

The profession of writing titles has all the dignity of a literary career—the audience is vast enough to appeal to the ambitions of any writer. The work calls for inherent as well as acquired culture and it may be recommended as a career to the young men from our universities. Even with their academic training, they will find it difficult to keep pace with the ever-increasing requirements of the craft. Yet they will have the satisfaction of knowing that their vocation is one that takes its place among the constructive works of the world.

The word sub-title is a rather loose term, commonly used to designate all reading matter, except the main or lead title, which appears on the screen. A more correct designation divides the term into two sub-headings: Captions, meaning all explanatory reading matter, and Spoken Titles, meaning all words put into the mouths of the characters and indicated by quotation marks.

When, where and why are sub-titles necessary or desirable? Some of the reasons for their use are:

1. To explain the purpose or indicate the main theme of the picture.

2. To give the picture coherency. They are links which join the scenes and help to carry the thread of the story.

3. To name and characterize the principle rôles portrayed; to identify setting or location, and sometimes to fix the time of the story or any of its parts.

4. To illuminate and interpret the picture or any of its situations by conveying ideas which the action does not or cannot register.

5. To inject comedy, pathos, or other sentiments which may be entirely arbitrary, into the picture.

6. To indicate lapses of time, or cover jumps in the continuity.

7. To economize footage or save production costs by substituting for scenes not shown.

Some of these uses, may appear to be similar and some of them may overlap. One sub-title may serve two or more of these purposes. On the other hand, a sub-title may be required for only one of these definite reasons.

There are as many ways of wording or phrasing a given sub-title of moderate length as there are individuals who may write it. Perhaps each one would consider his style and wording the best. It is certain that no two would write it exactly the same.

There is and can be no set rules to govern its composition and no definite standard by which it may be measured. Its final form must be dictated by the intelligence, judgment and experience of the writer.

There is wide diversity of opinion as to what constitutes a good and sufficient sub-title. Some people favor a florid or high-sounding style, while others advocate a condensed, almost abbreviated form. As a matter of fact, each kind may have its proper uses, depending upon the character of the story and its interpretation in the picture. The sub-title writer should endeavor to sense the atmosphere and characterizations of the picture as they are shown on the screen. He must make the titles fit the scenes as played, not as he thinks they should have or wishes they might have been portrayed.

Sub-titles should be fitted into a picture so that, instead of interrupting or irritating, they help the natural flow of the story and add to its interest. If they are too few or too short and abrupt they may defeat this purpose as effectually as when they are too numerous or too long. Everybody knows how interesting a spoken or written story may be when told by a master and how flat or insipid the same tale is when related by an unskilled narrator.

It is often much more difficult and takes more time and study to decide not to insert a sub-title than to write one. If a sub-title will not help a scene, or if one is not actually needed, it is safe to leave it out. It is not always as simple and easy to write a suitable sub-title to fit a given scene as it might seem to one who views the finished picture. It is much easier to write a long and flowery sub-title than one which is terse and expressive. A caption of moderate length, designed to cover several points, is often revised and rewritten a dozen times before it assumes satisfactory form. Sub-title writing has its nuisances as well as music and art. Words that may express the desired thought must sometimes be discarded because they are too long or unfamiliar to the average motion picture patron. The best captions and the most difficult to formulate are expressed in a few words of simple, correct English devoid of technical or uncommon terms.

Captions covering a considerable lapse of time should not be too short. There is a psychological reason for this. It may seem sufficient to cover a lapse of time by simply flashing "A Year Later" on the screen. If this short caption follows intense action or suspense, the audience should be given a little longer time in which to relax and to grasp the new thought before the next scene is shown. Therefore a caption containing from six to ten words may sway the trend of thought smoothly and pleasantly and without the mental wrench that the shorter caption might give the average person. Of course this does not apply when surprise is desired.

Often spoken titles present many difficulties. Witness the mushy, inane speeches put into the mouths of some characters in love scenes—speeches such as one would never make. The effort should be to write spoken titles that will seem natural and at the same time be in keeping with the character. A speech that may sound all right when actually spoken, with the advantage of inflection and emphasis, may seem very flat when thrown upon the screen.

Dialect-spoken titles are tricky and should be used sparingly. They are usually difficult to read and often fail to impress. Very few people can write any dialect with great success, especially for pictures. Probably no one can write all dialects satisfactorily.

Long spoken titles should be avoided as much as possible. Better to have two or three short ones than a single long speech, provided the scene will carry more than one. As a rule it is better to have one sentence, worded, punctuated, and spaced to read as smoothly as possible. Many spoken titles containing two or more sentences could be condensed into one by a little thought and study. But brevity may be overdone. It is often easier to catch the sense of a well-rounded sentence than one which has been clipped too short.

Title cards should be edited carefully by the title writer before they are photographed. The idea contained in a sub-title is often obscured by crowding, bad spacing, incorrect or unnecessary division of a word at the end of a line, (due to poor judgment on the part of the man who letters the cards), making the words hard to read or difficult to interpret readily.

Spoken titles should not be cut into long shots if it can be avoided because it is often difficult to be sure which person is speaking. If possible, flash to a close-up of the person talking, cut in the title, another flash of the close-up and then back to the long shot. A very short piece before and after the spoken title will accomplish this purpose and add very little to the footage. If a close-up is not available and the spoken title is essential to the scene then write it so that the audience may be sure which person speaks.

In writing sub-titles and also in cutting a picture keep the audience constantly in mind. Try to work from the point of view of the person who is going to look at your picture. Remember that the people seeing the picture but once will not be as familiar with it as those who have run it over and over while working on it, and that the public may not catch the fine points that have become quite familiar or obvious to you.

While a certain amount of latitude in language is allowable in spoken titles, captions should be written in good English and be correct grammatically. Study, analysis, judgment and experience are as necessary in writing good sub-titles as in any other department of picture production. Ability to write stories, advertising copy, letters or other forms of composition does not necessarily imply qualification to write satisfactory sub-titles.

ASSEMBLING—The most difficult part of the producing of a motion picture is the cutting and assembling of the print. Hundreds of directors are producing pictures which are really made in the cutting departments. If a director is a good film cutter and can follow the action of his picture on a pair of rewinders, the producer has something to be thankful for.

Directors who can cut their own pictures are few and far between. D. W. Griffith, Thomas Ince, Edwin Carew, George Tucker and Edgar Lewis are a few great directors who cut their own pictures, but it has taken them years to master this art.

The majority of directors make a child or a pet of pictures. To them the eliminating of this episode or that unnecessary scene is like cutting off the fingers or arms of a child.

If only directors would realize that a comedy situation is over after the laugh and a dramatic situation, after the suspense, and would bring the scene to a close, pictures would be easier to cut.

The use of close-ups in the midst of dramatic action is a mistake made by many directors.

In a certain picture a woman was roughly thrown to the floor and as the man's hand grasped her, the director cut to a close-up of the woman, thereby losing all the dramatic value and suspense of the scene.

*(Courtesy of the Universal Film Company)*

NEGATIVE CUTTING.

Close-ups are effective when used to depict emotion or thoughts and as introductions. They are necessary for switchbacks or suspense but should never be used when they break into dramatic action.

There are few film cutters who try to cut and edit a picture while watching it on the screen in a projecting room dictating to a stenographer. Eliminating this scene, shortening that, transposing this scene or that title, they think they are cutting the picture properly. No man can cut a picture properly unless he looks at it once or twice in the projection room and then personally goes over the entire film by hand, on a pair of rewinders. Then when he comes to an unnecessary scene he can eliminate it but first he must be sure that the next scene or title will not break the continuity of action. If a scene drags or is too long, he must ponder over that scene, sometimes imaging himself one of the characters in order to think of a proper title. He personally must insert the title so that it will seem to come from the correct character when projected on a screen.

Dramatic switchbacks are a physical impossibility unless a cutter personally arranges the scenes. If his assistant does this, he is the real cutter and it is mere luck if he gets the title inserted perfectly.

A film cutter must be able to write and originate comic and dramatic titles. He must also know the proper color schemes for each scene in order to cut the negatives properly when the positive print is ready for the laboratory.

# EXTERIOR LIGHTING

## Chapter XIII

WHEREVER a camera has to be taken out for photographing at a distance, great care must be taken to make sure no essential part of the kit is left behind. Make a list beforehand of everything which will be required. A good way of recollecting minor items of kit in danger of being overlooked is to act over to yourself each stage of the work before you, asking of every accessory: "Have I that on my list?" Thus:

I am going to make scenic pictures. I pack the camera in its *case,* strap up the *tripod,* and start. I take a taxi to the railroad station. (Note: Have I money to pay the taxi, and buy my ticket?) At my journey's end I select a good view and set the camera up by erecting the tripod, *screwing* on camera, and attaching *camera, tilting,* and *panoram handles,* (Have I all three?) Next I focus. That means *focusing celluloid.* I thread up film, for which I require *film* and *take-up* boxes and as many *spring clip hubs* for the take-up spindles as there are charged film boxes. I find the exposure with my *exposure meter.* Now to take the picture. I place my hand on the *camera handle,* look through the *view finder* (Have I this, too?) and the filming is done.

Write out a full list of usually required accessories and keep it where it can be referred to easily. The inside of camera door, and the top of camera case are both good places for it: Camera, camera handle, camera tripod, film boxes, take-up boxes, exposure meter, view finder, focusing celluloid, extra lenses, tripod handles, film clip hubs for take-ups, soft rag and camel-hair mop brush for dusting camera and lens, emery for cleaning gate, etc., etc.

Though good, correctly managed, lighting is a necessity of high quality negative making, it becomes a distinct art in scenic work, therefore I shall deal with it more particularly under this head. Three fundamental rules of lighting to bear in mind when photographing any subject are that the light must be sufficient, its quality must be actinic (it must be rich in the photographically active blue and violet rays) and the source of light must on no account shine directly in at the camera lens. Whether or not the first two of these rules is fulfilled can best be decided by the aid of an exposure meter. Decide the third point by common sense. If the light source, usually the sun, is beating directly into the front glass of the lens, the lens must be shaded by means of a dark hood. If that is not practicable without cutting off a portion of the picture, the camera's position must be shifted. Where this also is impracticable or undesirable, and the subject is one which can be photographed at more than one time of day, select a time when the direction of the sun will have altered and postpone filming till then.

To focus a dead sharp image of those objects which must be sharp upon the film, and to make the focusing accord with a near approximation of correct exposure, is a real stumbling block to a great number of would-be camera operators. A man who knows how to make focusing help exposure and exposure help focusing must possess both considerable practical experience and a quantity of judgment.

To focus correctly:

Open the camera gate, remove film from film track and lay in its place a length of three or four inches of matt celluloid.

Matt celluloid can be made from any clipping of old cinematograph film. Soak the film in warm washing soda solution till the emulsion softens. Clean off, and dry the cleaned base. Make a paste of knife powder and water, smear it on a piece of glass, lay the transparent celluloid down upon the paste and rub the film in the emery by placing your fingers on the back and rubbing with a circular motion. After a short while the celluloid will no longer be transparent on the side that has been scratched. It is then suitable for a focusing screen.

Next close gate firmly upon the matt celluloid, adjust focusing tube and magnifier tight up in place, open light shutter of focusing tube, place your eye to the end of it and, unless the rotary camera shutter is cutting the light from gate, you will see a more or less clear image thrown by the lens. If no trace of an image is visible a slight turning of the camera handle will make it so.

Turn the lens focusing flange, or rack, till the image becomes quite sharp and then begins to become less sharp again. Then reverse turning direction of the focusing adjustment till the image once more sharpens up to its best. In this way, the point of *critical* sharpness for the particular object focused upon is found. If at first you have difficulty in deciding the critical point, get a large white card and stick upon it criss-cross strips of dead black paper. Stand the card up against the object you are focusing. Black bars on a white ground are easiest of all things to focus clearly.

Always do your focusing with the lens diaphragm open at its widest aperture. Take careful note of the apparent brightness of the picture produced, as practice in this will help you a little in judging exposure should you ever be called upon to do so when you have not your meter with you.

Notice that objects nearer to, and probably also objects farther from, the lens than the one focused upon are not sharp on the celluloid but are fuzzy.

To focus other objects with the principal object:

The object is not merely to focus a single subject sharp but to adjust the lens at the same time so as to get reasonable sharpness of objects both before and behind it.

The method is the same whether we want subsidiary sharpness in objects nearer or farther off than the principal one.

To focus a good compromise between principal and nearer objects, first get principal object critically sharp, then rack out the lens very slightly until a barely perceptible falling off in the principal object is seen.

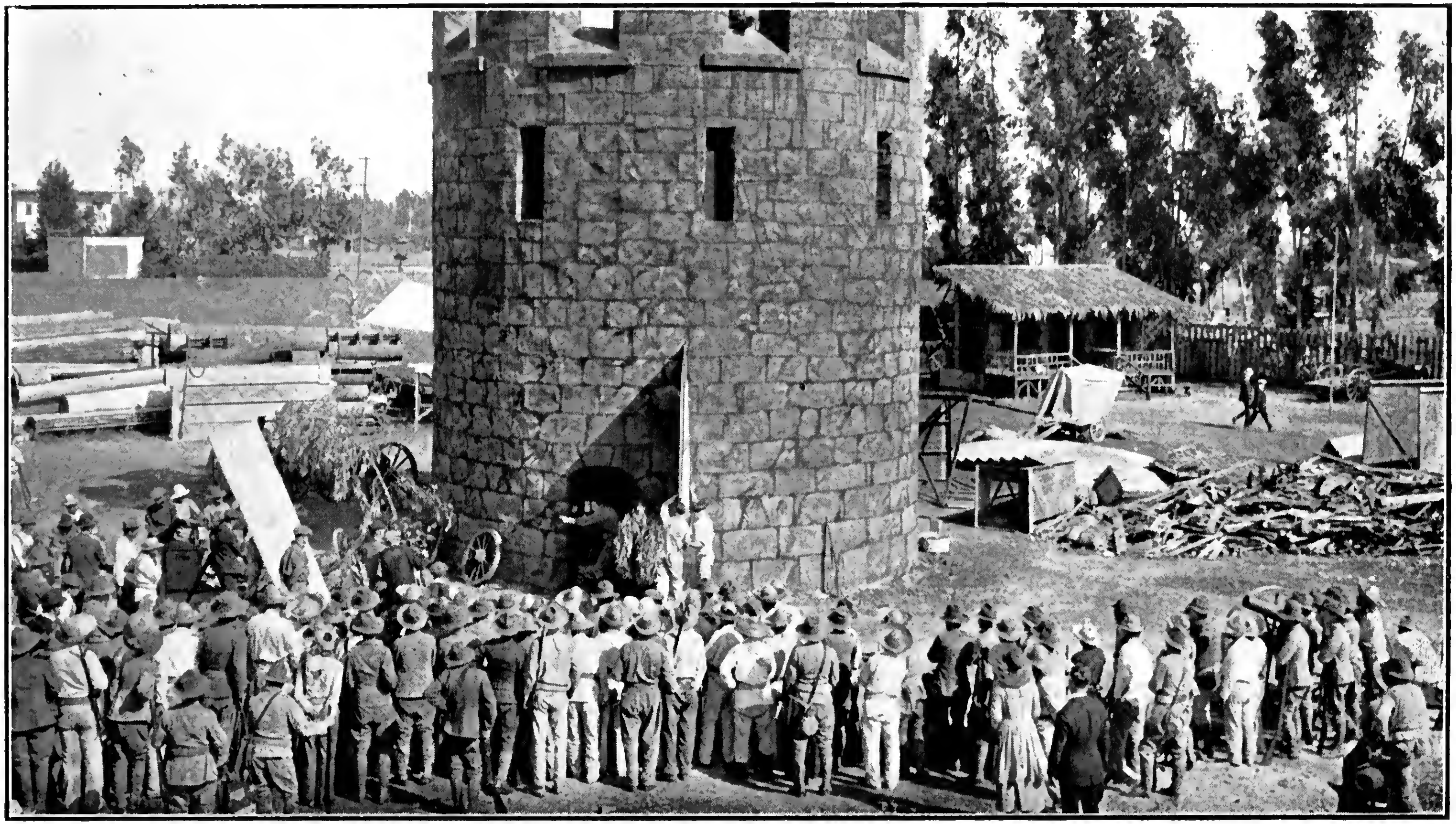
To focus principal and farther objects get principal sharp and rack lens slightly in.

The amount of racking out or in to make correct compensation for depth of stage is very slight. Where possible follow it by substantially reducing lens aperture. Always compensate for depth first and reduce aperture afterwards.

One of the greatest difficulties encountered by the photographer, whether he wields a still camera or turns the crank of a motion picture box, is that of exposure.

Gelatine emulsions are of different speeds and latitudes and subject to deterioration. The celluloid base from which motion picture film is made and which is also extensively used for film cartridges, film packs and as cut films, reacts upon the emulsion and causes it to gradually lose its sensitive qualities in much more rapid ratio than that of emulsions coated upon glass.

An emulsion records the amount of light which acts upon it



(*Courtesy of Fox Film Corporation*)

THEDA BARA IN "UNDER THE YOKE." NOTE THE SCREEN WHICH IS BEING HELD AT AN ANGLE BACK OF THE CAMERA TO GET THE PROPER LIGHT REFLECTION.

in a definite mathematical ratio, but one emulsion may be "faster" than another. For example, if two plates or pieces of film are taken, one of which is twice as fast as the other, and both are exposed for a short time at equal distance from a standard candle, the faster emulsion will show a much greater density on development than the slower one. If, however, the slower one is exposed twice as long the two pieces will have equal density.

It is highly important in making tests of any character in photography that every factor in making relative tests be reproduced exactly or the results obtained will be false.

Development, time and temperature must be controlled exactly, fresh standard developer being used for each test as it deteriorates with use; fixing, washing and drying times and temperatures must also be the same. A test made in cold developer and another in warm easily give rise to false conclusions in regard to the speed of a film or plate. Many photographers have been grievously misled in their conclusions in regard to materials by inaccurate tests.

Inasmuch as different emulsions require different developing times to record gradations of light in their true ratio, it is necessary to make preliminary tests to ascertain the development time where it is not given by the maker.

Where photometric instruments are not at hand for accurate tests the simplest method of arriving at the proper development time is to expose a strip of film giving relative exposures of 1, 2 and 4. Cut the film lengthwise in three strips. If you think five minutes to be about the normal development time, develop the three strips 4, 5 and 6 minutes respectively. If you have been lucky in your assumptions as to the speed and time, one of the nine permutations obtained will be correctly exposed and developed, giving a basis for farther experiment. If the nine permutations are all too dense, the exposures have been too long. Try again with shorter exposures; if there is much fog or stain, the development may have been too long. Try again with shorter development. If the strongest exposure and longest development is the best of the nine, try again with longer exposure and longer development times.

Many methods have been worked out for determining proper exposure. The following data is largely taken from material collected by A. Horsley Hinton, formerly editor of the *Amateur Photographer.*

The principal factors governing exposure are: (1) the speed of the plate; (2) the actinic power of the sun's light for the time of year in a given latitude and its position at the particular time of the day; (3) the effective diaphragm aperture of the lens; (4) the nature of the subject and its illumination as affected by local and atmospheric conditions. With others these data are supplemented by, and practically based upon, actino-metric observations of the action of the light upon sensitive paper exposed near the camera or the subject at the time. Both methods are in many cases of undoubted use, but the information given by instruments of this kind can only be considered as approximate, and much is left to the judgment of the operator, whose surest guide will be an intelligent study of the principles on which these instruments are based, together with carefully recorded observations of the combined working of his lenses, shutters, plates and methods of development under the varying conditions of practical work. Before using any of these instruments it is necessary to know approximately the relative sensitiveness or "speed" of the plate or film in use. In the early days of gelatine dry plates their rapidities were stated as so many times those of wet plates, or (as they are still) "ordinary," "instantaneous," "rapid," or "extra-rapid," terms which, though suitable for one make of plate, may not be so for others.

In 1890, F. Hurter and V. C. Driffield introduced an entirely new system of calculating the sensitiveness of plates of different rapidities. They make a series of exposures in seconds on different parts of the plate in geometrical progression with a standard candle at one meter distance. After development for a certain fixed period with a standard developer, fixing, washing and drying, the "densities" or logarithms of the opacities of the different parts are measured by a special photometer and plotted on a skeleton diagram, producing a curve, one portion of which will be practically a straight line. (See the chapter on Negative Development). The position of this line with reference to a scale of exposures given on the diagram decides the rapidity of the plate, while its length indicates the "capacity" of the plate for truthful rendering of tone.

It is to be deplored that no universally recognized system of speed numbers has been brought into use, nearly every maker of films and plates having some system of his own which bears no relation to that used by other manufacturers.

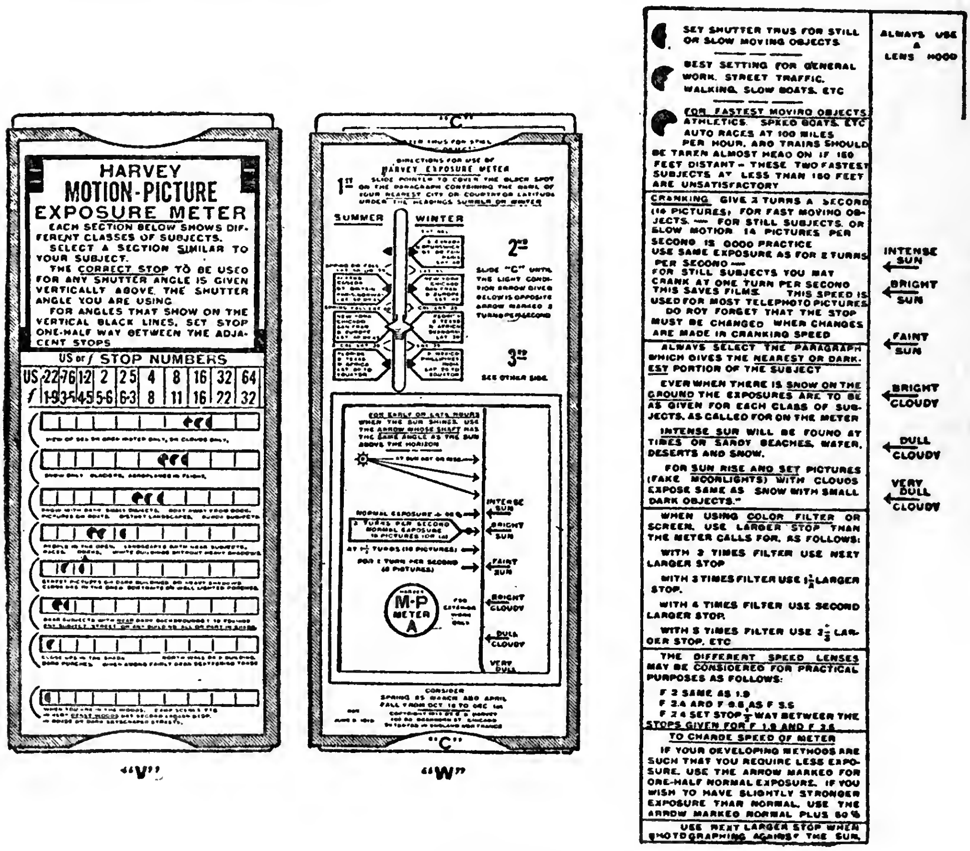
The H. and D. system is probably the most scientific one.

The sensitiveness shown on the H. and D. scale is directly proportional to the speed number given. The method has been adopted by several dry-plate makers in denoting the sensitiveness of their different brands, and is more or less the basis on which the plate-speeds for the modern dry-plate actinometers and exposure meters are calculated.

Variation in daylight without clouds from morning until evening (for latitude of Northern United States):

| | Morning | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 |
| January | 3½ | 4 | 5 | 12 | .. | .. | .. | .. | .. |
| February | 2 | 2½ | 3 | 4 | 10 | .. | .. | .. | .. |
| March | 1½ | 1½ | 1¾ | 2 | 3 | 6 | .. | .. | .. |
| April | 1¼ | 1¼ | 1¼ | 1½ | 2 | 3 | 6 | .. | .. |
| May | 1 | 1 | 1 | 1¼ | 1½ | 1½ | 3 | 6 | .. |
| June | 1 | 1 | 1 | 1 | 1½ | 2 | 2½ | 5 | 12 |
| July | 1 | 1 | 1 | 1¼ | 1½ | 2½ | 3 | 6 | .. |
| August | 1¼ | 1¼ | 1¼ | 1½ | 2 | 3 | 6 | .. | .. |
| September | 1½ | 1½ | 1¾ | 2 | 3 | 6 | .. | .. | .. |
| October | 2 | 2½ | 3 | 4 | 10 | .. | .. | .. | .. |
| November | 3½ | 4 | 5 | 12 | .. | .. | .. | .. | .. |
| December | 4½ | 5 | 6 | .. | .. | .. | .. | .. | .. |
| | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | Afternoon | | | | | | | | |

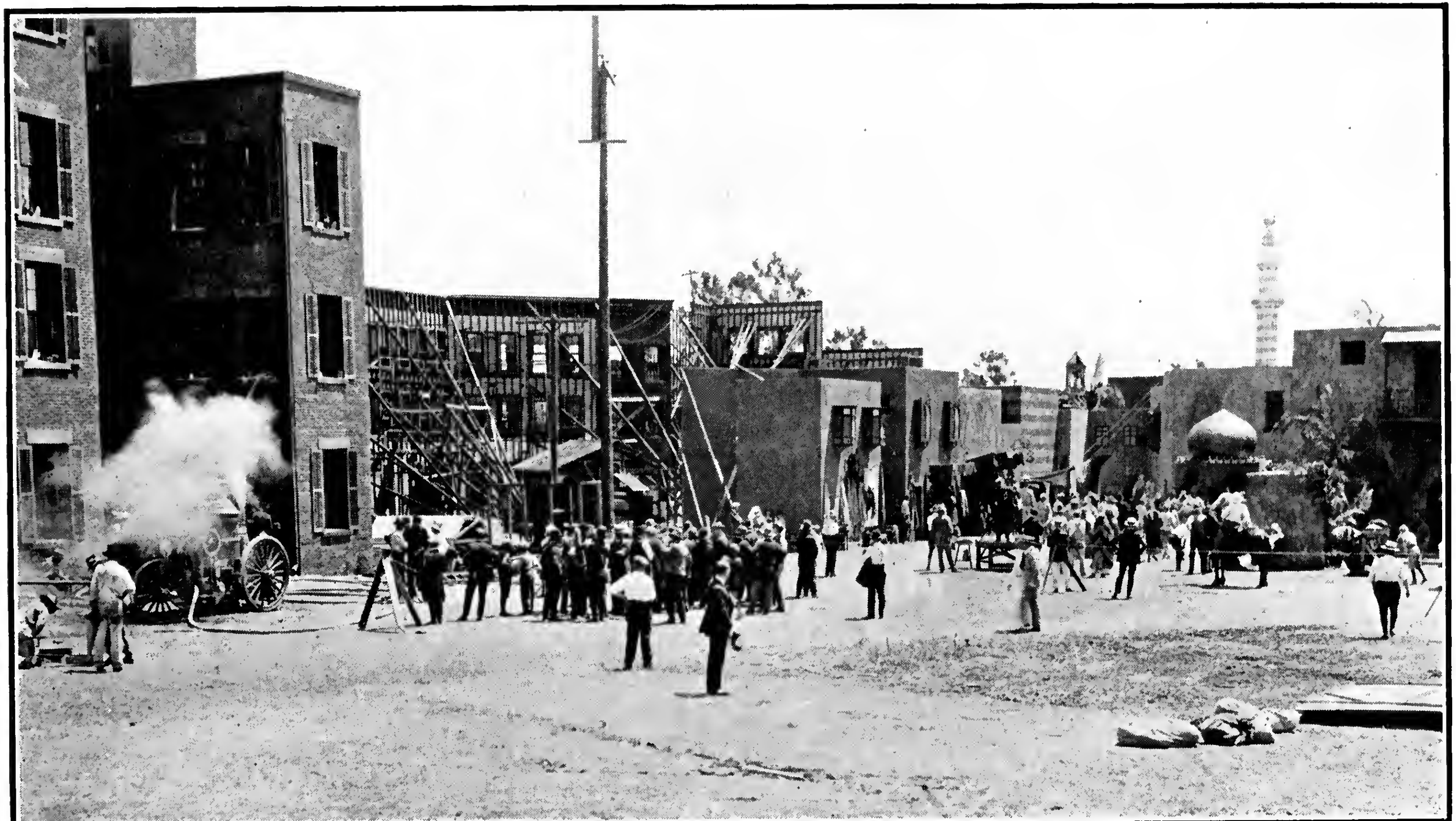
The next important factor is the actinic power of the light. It depends normally on the height of the sun for the latitude of the place at the time when the photograph is taken, and exposures in bright sunlight are found to vary approximately as the consecant of the sun's altitude above the horizon. The light of the sun itself is practically the same at any given time and place year after year, but is liable to more or less local and temporary diminution by the amount of cloud, haze, dust, etc., present in the atmosphere at the time. It is also affected by the time of day, increasing from sunrise to noon, and then decreasing to sunset. The remaining factor is the effective diaphragm aperture of the lens in relation to its focal length. In most cases of ordinary out-door exposures this can be taken at its normal value, but becomes smaller and increases exposure if the focal length is much increased for photographing near objects. Besides these principal factors, the nature and color of the objects, their distance and the amount of light received and reflected by them under various atmospheric conditions, have a great influence on the exposure required.




"V" "W"

Fig. 42

The American Photography Exposure Tables are the most convenient and practical help in determining the correct exposure for any subject, in any part of the world. An edition has been carefully revised to include all the films and plates on the American market. In every instance the speed has been determined by scientific tests by a renowned expert. The tables assign to each factor concerned in exposure—subject, stop, light, hour and plate—a number. These are found in the tables and added. No multiplication is necessary. The sum is then looked out on



*(Courtesy of Robert Brunton Studios)*

SHOOTING TWO LARGE EXTERIOR SETS IN LOS ANGELES, CAL. THE SET ON THE LEFT IS A CAIRO STREET. THE STREET ON THE EXTREME LEFT IS A NEW YORK ALLEYWAY OF THE TENEMENT DISTRICT BEING USED BY DOUGLAS FAIRBANKS.

a final table, and opposite this number is found the exposure in fractions of a second, minutes or hours.

Based on the same principle as these exposure tables, various portable exposure meters have been brought out, in which scales representing the coefficients for plate-speed, light and diaphragm are arranged as in a slide rule, so that, when properly set, the normal exposure required can be found by inspection, and increased or diminished according to circumstances.

The Harvey meter and the Burroughs & Wellcome meter and handbook are for sale by every photographic supply house.

The Watkin's Kinematograph meter is fitted with a pendulum for counting half seconds and crank turns. It is made especially for motion picture operators and is about the size of a small watch. It gives a direct reading showing either the shutter opening or diaphragm number required under the given conditions. It is sold by Burke & James, Chicago, as are the Wynne meters described below.

G. F. Wynne's "Infallible" exposure meter is also in dial form, but the sensitive paper is exposed directly, no pendulum is used, and the scales are open on the dial. In use, the glass carrying the movable scale is turned until the actinometer time in seconds upon the exposure scale is opposite the diaphragm number of the plate, as given in the list of plate speeds; the correct exposure will then be found against each stop given on the scale. There are practically only two scales; the scale of diaphragms representing the diaphragm or f numbers, the speed of plate and the variation of exposure due to subject; and the time scale, representing the actinometer time and the exposure. The actinometer is protected by a yellow glass screen when not in use. In a smaller form the scales are on the circumference of a locket, and the actinometer at the back. An "Infallible" Printmeter is also made for showing exposures in contact printing on sensitive papers, but can also be used for testing speeds of plates and papers. Beck's "Zambex" Exposure Meter gives the exposure and stop to be used, also the depth of focus to be obtained with different diaphragm apertures. The required exposure is set to the "speed" number on the next scale of the meter. The third scale corresponds to the times of darkening the sensitive paper in the actinometer attached to the meter, and shows the diaphragm aperture suitable for the given exposure. Other scales show the distances that will be in focus with the different stops used, arranged so that the focal depth of four different lenses can be found. Several other exposure meters are made on the principle of the slide rule, with scale corresponding to the factors of "plate speed," "diaphragm number," "light," "exposure," and the exposure is found by simple inspection without an actinometer. They are designed for use with particular brands of plates, but can be used for others of similar speeds.

The last types of meters described depend for their light measurement upon matching a tint or shade, a rather difficult matter for most persons. A new instrument based on the same principle, but which does not require the tint to be matched, is the Steadman Aabameter. It may be obtained from any photo supply dealer. It consists of a series of graduated openings which give a ratio of exposure upon a strip of sensitized paper in the progression of 1, 2, 4, 6, 8, 16. The number of gradations recorded in a given time gives the light strength and reference to a simple chart tabulated on a card, and gives the proper exposure at a glance.

Another class of exposure meters comprises those in which the intensity of the light is estimated visually by extinction through a semi-transparent medium of increasing intensity, such as J. Decoudin's, in which the exposure is judged by the disappearance of a series of small clear openings on a graduated scale of densities when laid on the most important part of the image as seen on the ground-glass. Its indications are not very definite, and the proper scale changes in density after a time. A better form is "E. Degen's Normal Photometer," consisting of two sliding violet glass prisms, one adjusted for the diaphragm apertures, the other for the actinic illumination of the object. They are mounted with their outer faces parallel.

In use the upper slide with prism is drawn out so that the pointer coincides with the division indicating the diaphragm aperture to be used: the object to be photographed is then viewed directly through openings at one end of the instrument, and the lower slide is drawn out and pushed back slowly till the object viewed is almost obscured. The attached pointer will then indicate the exposure required, or, reversing the order, the diaphragm aperture for a given exposure can be found. Auxiliary scales are attached for very short or very long exposures. The principle of construction is that the logarithms of the times of exposure are proportional to the thickness of the colored prisms. "G. Heyde's Actino-Photometer" is on a somewhat similar principal, and consists of a circular metal box with dark violet glass viewing screens in the center of both sides, with obscuring iris inside the case worked by revolving the back of the box. On the front of the instrument exposure tables are given for plates of every rapidity, and for diaphragm apertures from f/3 to f/45. Exposure meters of this type are specially applicable for open-air work where there is sufficient light for ready measurement.

Practically all of the commercially sold meters give the exposure in a manner suitable for still camera work, which is seldom convenient for the cinematographer.

The following table gives the diaphragm number and shutter opening graduated from the exposures usually given for still camera work. Where longer exposures are recorded for still cameras it is not possible to get full exposure with the motion camera. It is understood that the calculation originally made with the meter is for a still camera using plates of the same relative speed as cine emulsion, which is as fast as the fastest plates ordinarily used in stand cameras, the only exception being the ultra-fast plates sometimes used for Graflex work.

*Table of Comparative Exposures for Still and Motion Cameras.*

| | sec. | sec. | sec. | sec. | sec. | sec. | sec. |
|---|---|---|---|---|---|---|---|
| **Still camera at f16** .......... | 1 | 1/2 | 1/4 | 1/8 | 1/16 | 1/32 | 1/48 |
| Motion camera: | | | | | | | |
| ½ opening shutter .......... | F3.5 | F4 | F5.6 | F8 | F11 | F16 | F22 |
| ¼ opening shutter .......... | ... | F3.5 | F4 | F5.6 | F 8 | F11 | F16 |
| ⅛ opening shutter .......... | ... | ... | F3.5 | F4 | F 5.6 | F 8 | F11 |

for ⅓ opening shutter the diaphragm should be set half way between the reading for the ½ opening and the reading for ¼ opening.

With a little calculation almost any reliable exposure tables may be used for the motion picture camera. As the shutter revolves sixteen times per second it requires one-sixteenth second for the shutter to turn once; if it has an opening which is one-half of the circumference the exposure given is one-half of one-sixteenth or one-thirty-second; a one-third opening, one-forty-eighth, etc. Now the diaphragm numbers on a lens, whether they be U. S. or F system, are arranged so that each higher number gives just half the exposure of the one below it. Also, U. S. 16 and F 16 are equal. Now let us figure: Suppose

**An exposure chart for motion picture work is given here. F system is used.**

| Month and Weather | | 11 A. M. to 1 P. M. | 10–11 and 1–2 | 9–10 and 2–3 | 8–9 and 3–4 | 7–8 and 4–5 | 6–7 and 5– | 5–6 and 6–7 |
|---|---|---|---|---|---|---|---|---|
| Jan., Nov., Dec. | Bright Sun | 22 | 16 | **11** | | | | |
| | Hazy Sun | 16 | 11 | **8** | | | | |
| | Diffused light | 11 | 8 | **5.6** | | | | |
| | Dull | 8 | 5.6 | **4** | | | | |
| | Very Dull | 4 | 3.5 | | | | | |
| Feb., Oct. | Bright Sun | 22 | 16 | 11 | **8** | | | |
| | Hazy Sun | 16 | 8 | 5.6 | **5.6** | | | |
| | Diffused light | 8 | 5.6 | 4 | **4** | | | |
| | Dull | 5.6 | 4 | 3.5 | **3.5** | | | |
| | Very Dull | 4 | 3.5 | | | | | |
| Mar., Apr., Aug., Sept. | Bright Sun | 32 | 32 | 22 | 22 | 16 | **11** | |
| | Hazy Sun | 22 | 22 | 16 | 16 | 11 | **8** | |
| | Diffused light | 16 | 16 | 11 | 11 | 8 | **5.6** | |
| | Dull | 11 | 11 | 8 | 8 | 5.6 | **4** | |
| | Very Dull | 8 | 8 | 5.6 | 5.6 | 4 | **3.5** | |
| May, June, July | Bright Sun | 32 | 32 | 22 | 22 | 11 | 8 | **5.6** |
| | Hazy Sun | 22 | 22 | 16 | 16 | 8 | 5.6 | **4** |
| | Diffused light | 16 | 16 | 11 | 11 | 5.6 | 4 | **3.5** |
| | Dull | 11 | 11 | 8 | 8 | **4** | 3.5 | |
| | Very Dull | 8 | 8 | 5.6 | 5.6 | 3.5 | | |

our table of exposure says that under the conditions that obtain where we wish to work that the normal exposure is one-fourth second at U. S. thirty-two. The next lower stop is U. S. 16, which is twice as fast, therefore, at U. S. 16 we can expose in one-eighth second. Now our cinematograph lens is perhaps marked in the F system. F 11 is next below F 16 with an exposure of one-sixteenth second. The most we can give is one-thirty-two second with our shutter as far open as we can use it, we must open our diaphragm still further in order to get enough light through our lens to make the picture in one-thirty-two seconds. F 8 is the next diaphragm number giving an exposure in half the time as F 11; one-half of one-sixteenth is one-thirty-two, therefore, if we set the diaphragm at F 8 and turn at normal speed we will have a correctly exposed negative.

In regard to exposure in back lighting: In calculating exposure for back lighting it is usual to calculate the exposure for the lower tones in the picture, as the high lights where the sun strikes are always over-exposed. It is practically always necessary to use a lens hood or some sort of shield to protect the lens from the direct rays of the sun. When the sun sets low enough to be included in the picture it is then usually too dark for back lighting, and the effect then becomes either silhouette or moonlight effect. It is customary in most back lighting effects to light up the shadows by an inclined reflector placed between the foreground and the camera. Back lighting generally takes two to four times the exposure necessary in the same light when used in direct lighting.

This chart is calculated to give full shadow detail, at sea level, 42° North Latitude.

For altitudes up to 5,000 feet no change need be made. From 5,000 to 8,000 feet take ¾ of the time in the table. From 8,000 to 12,000 feet use ½ of the exposures in the table.

Exposure for average landscapes with light foreground, river scenes, light colored buildings, monuments, snow scenes with trees in foreground. The data compiled for use with Eastman's standard motion picture film and cemeras with 50 per cent shutter opening.

The exposures given are approximately correct, but usable negatives can be obtained with ½ and ⅔ less time where it is not possible to give more on account of small apertured lens or ¼ opening shutter. Allowance should be made, however, for smaller shutter opening whenever possible.

Forty-two degrees North Latitude is that of New York and the Northern States. For Southern Canada use next larger sized stop and in the winter months perhaps two sizes larger. For Southern California, Florida and the Southern States, the next size smaller will be sufficient generally except in the early morning and late evening hours, when the opening shall be according to the chart or even increased. When the light is red or yellow where the indicated stop numbers are underlined, the diaphragm opening must be increased to the next or even to the second or third opening beyond that indicated by the chart.

The numbers given in the chart indicate the diaphragm opening necessary under the F system, which is the system used in marking the diaphragm opening on nearly all cinematograph lenses. They are F 3.5, F 4, F5.6, F 8, F 11, F 16, F22, F 32—each succeeding number in this series giving one-half the exposure of the one preceding. Other intermediate numbers are sometimes given, but not often, and may be disregarded practically when using this chart. In the following classification of subjects, the diaphragm opening should be modified from the one given in the chart according to the direction given after each class.

For example, we wish to make a picture in June, at four o'clock in the afternoon, of some red brick building on a hazy day. Under June we look in the hazy sun column and opposite the time we find the exposure to be F 16. For this classification the increase is two points, or F 8.

*Subjects*—For other subjects modify the exposure for an average landscape as given for the class of subject.

*Class A*—Studies of sky and white clouds. Decrease opening three points.

*Class B*—Open views of sea and sky; very distant landscapes; studies of rather heavy clouds; sunset and sunrise studies. Decrease opening two points.

*Class C*—Open landscapes without foreground; open beach, harbor and shipping scenes; yachts under sail; very light colored objects; studies of dark clouds; snow scenes with no dark objects; most tele-photo-subjects outdoors; wooded hills not far distant from lens. Decrease opening one point.

*Class D*—Landscapes with medium foreground; landscapes in fog or mist; buildings showing both sunny and shady sides; well lighted street scenes; persons, animals and moving objects at least thirty feet away from the camera. Increase opening one point.

*Class E*—Landscapes with heavy foreground; buildings or trees occupying most of the picture; brook scenes with heavy foliage; shipping about the docks; red brick buildings and other dark objects; group outdoors in the shade. Increase opening two points.

*Class F*—Portraits outdoors in the shade; very dark near objects, particularly when the image of the object nearly fills the film and full-shadow detail is required. Increase opening three points.

*Class G*—Badly lighted river banks, ravines, glades and under the trees. Wood interiors not open to the sky. Increase opening four to five points. For back lighting and Rembrandt effects, give an additional increase of one more point than indicated by the classification.

Subjects which require openings much greater than afforded by the lens used should not be attempted or the film is only wasted.

## CHAPTER XIV

# INTERIOR LIGHTING

TWELVE years ago there were probably only five studios for the production of films where there are now more than one hundred. The large amount of money which has been made in this industry and the possibilities of future profits have drawn capital for the formation of new enterprises from various sources, and with the creation of so many new companies, competition has become keen, and the cost of producing films has become an important factor.

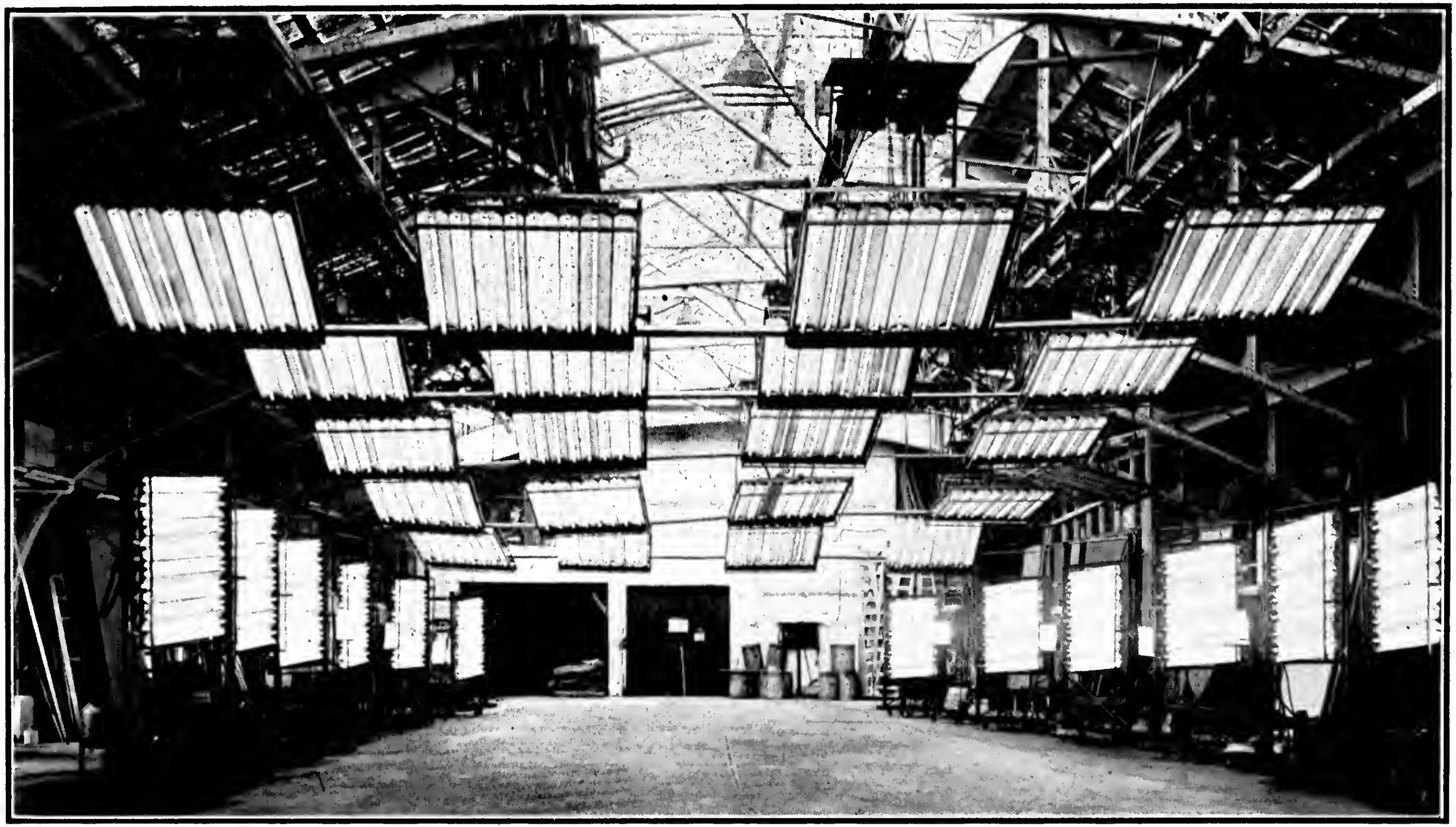
In the making of a picture the costs may roughly be divided into: cost of raw film; interest and depreciation charges on buildings and equipment; salaries of directors, actors and mechanics; cost of developing and printing, and the cost of lighting.

Just what relation these various costs bear to one another is doubtful, but it has been stated that completed films cost to make anywhere from 50c. to $5.00 a foot, the average being approximately $2.00 per foot.

The raw film itself costs about 3½ cents per foot for the negative and 3 cents per foot for the positive. Naturally the highest cost is for labor, and in this respect the moving picture industry does not differ materially from many other manufacturing processes. Any manner in which labor costs can be kept down and labor utilized to its fullest capacity, is bound to decrease the cost of the film and increase the profits of the manufacturer.

One item which tends to help utilize labor to its fullest extent is proper light. The first maxim in the studio is that "no picture can be made without proper light and plenty of it." Sufficient light has to be provided, whether it be daylight or artificial light, to take clear pictures in approximately 1/50 of a second. They must be taken with detail, as they are projected to a magnification of about 150 diameters on the screen, and the public is becoming more and more critical regarding proper definition of the subject projected.

The stop used is generally about f 4.5 with a 2-inch lens, and



*(Courtesy of Metro Studios)*

STUDIO USING MOSTLY COOPER-HEWITT MERCURY VAPOR LIGHTS. BETWEEN THE SIDE BANKS MAY BE SEEN SEVERAL WOHL FLOOD LAMPS. NOTE THE CRANES BY WHICH THE OVERHEAD BANKS MAY BE MOVED ABOUT.

if there is not an abundance of light, the picture will not be satisfactory when the camera is working at the required speed.

The indoor studios depended on daylight for their lighting by the use of glass skylights; later, studios were constructed not only with overhead lighting, but with the sides also of glass. Even under these conditions, on rainy or cloudy days, or about three o'clock in the afternoon during the autumn and winter months, the daylight available was insufficient to produce good pictures.

At about this period the Cooper-Hewitt Lamp had been developed, and its high actinic values were justly appreciated by the few studio managers who were then in the business, and an installation of these lamps was made in 1905 at the Biograph Company's original studio on 14th Street, New York City. From this installation has come the practical development of the Cooper-Hewitt Lamps for the moving picture stage.

Few people who see the films on the screen appreciate what has to be done to take even the simplest scene, after a scenario has been accepted by a company and turned over to the director who is the successor of the stage manager. The actors must be selected for the various parts and given instructions; scenery must be found for the setting, or if necessary, new flats, etc., painted, and erected on the stage. The necessary "props" must be obtained, and after rehearsing the scene time and again until the producer is satisfied, he calls for "Lights" and then for "Camera," and the picture is taken. Fifty or sixty feet of film, which require about one minute to photograph, may have taken two or three hours to rehearse. All scenes occurring in the same set are generally taken one after another irrespective of how they occur in the scenario, and after developing, the sections of the films are jointed together in their proper places.

The importance of light is emphasized by the statement that no matter how good the scenario may be, or how well it may be worked up, the result of the efforts of the producer and actors will not register clearly and accurately on the film if the action is not properly lighted.

One of the most efficient ways to light a stage either wholly dependent on artificial light or using it in conjunction with daylight is by means of Cooper-Hewitt Lamps arranged in banks, say, eight tubes. Each of these banks throws a mass of light upon the scene similar to that from a fair size window or skylight.

The Cooper-Hewitt Lamp is particularly desirable for this class of work on account of the great actinic power of the light; for equal illumination, it being about the same as daylight. Also the fact that the light comes from a long tube in place of being concentrated in a small point, ensures thorough diffusion of the light and gives a lighting effect similar to daylight. The light blends with daylight, and where used in a daylight studio can gradually be added as the daylight decreases.

Even with two or three hundred lamps on a stage there is very little glare, and no harmful effects are produced on the eyes of the actors. Furthermore, even with this large amount of light, the temperature of the stage is only slightly raised above the surrounding atmosphere. This is a most important point to be considered in taking pictures, and especially in fairly long scenes, as the fatigue produced by an excess of light will prevent the players from putting forth their best efforts.

Lamps are frequently arranged in skylights for hanging from the ceiling to provide top light, and floor stands are added to take care of the side lighting and reinforce the lighting at special points to obtain the best effects. By properly arranging the lights around the sides of the stage and overhead, modeling effects can be produced which do away with the flat pictures apt to result from improper lighting.

As an instance of the manner of lighting a studio for large stage work, we may take a stage of about 32 ft. deep. In a typical installation of this type there are 208 tubes, 136 for overhead lighting and 32 for high side lighting, with 48 mounted in floor stands for moving about to throw the light from one side and towards the front.

The overhead lamps are arranged in the following manner—Eight tubes in two banks are hung approximately 8 ft. over the front line, at an angle of about 30 degrees inclined toward the stage; back of these lamps are hung three banks of eight lamps, each at the same angle, and this idea is carried out so that at the back line there are four banks, at about 18 ft. above the stage, this fan-shaped method being essential to cover the stage. On one side are four hanging banks which are inclined 45 degrees, throwing the light in on the stage. No lamps are placed opposite to these, for the reason that if the illumination was equalized the picture would photograph flat. The floor-stands are placed at various positions to get light in on the stage to light up spots where the top and side lighting do not reach and to produce artistic modeling.

The overhead lamps in this studio are all suspended from a trolley system which permits the lamps to be removed from one end of the studio to the other, and cover in this manner three different stages. By this method scenes can be set up on two stages while pictures are being taken on the third, and no time is lost between the taking of the scenes.

The overhead structure for this work consists of three tracks running the entire length of the studio. On this track are run a number of grooved wheels which are linked together by three angle iron frames. From these three frames are suspended by chains, the skylight banks and their auxiliaries or starting apparatus. The iron frames are controlled by endless wire cables running from one end of the studio to the other, and which are connected to winches, so that the overhead frames can be moved about very readily, when desired, by turning the handles.

The wiring is run to a panel board, mounted at one side of the studio, and this panel is arranged so that all of the lamps can be thrown on at one time, or by a system of double throw switches, by throwing certain switches, any number of the lamps can be left on, the balance thrown off, or vice versa. This arrangement permits the dimming of lights for night scenes, or by throwing on all, gives the impression of the sun coming up, or the turning on of lights in a room.

In addition to Cooper-Hewitt Lamps a studio should have a number of arc lamps, several spot lights, which can be used in conjunction with the tube lamps for spot lighting effects. Moreover, arc lamps are used for fireplace lighting, table lamps, and other special effects.

Arc lights are also often used without the admixture of Cooper-Hewitts, as many effects can be produced with them which cannot be obtained with the diffuse illumination from the mercury tubes. The following paragraphs about "hard" lights are an abstract from a paper on "White Light for Motion Picture Photography," delivered before the Society of Motion Picture Engineers by William Roy Mott, of the Research Laboratory of the National Carbon Company, Inc., Cleveland, Ohio.

The famous psychologist, Professor Munsterberg, wrote a few years ago a book on moving pictures and in it he asserted that the production of moving pictures by the best companies had graduated as an art ranking with painting, sculpture and music. By attention to mode and variation of lighting, many new psychological appeals can be made, including the portraying of the thought images in the minds of the characters of the play, something impossible to duplicate on the theatre stage.

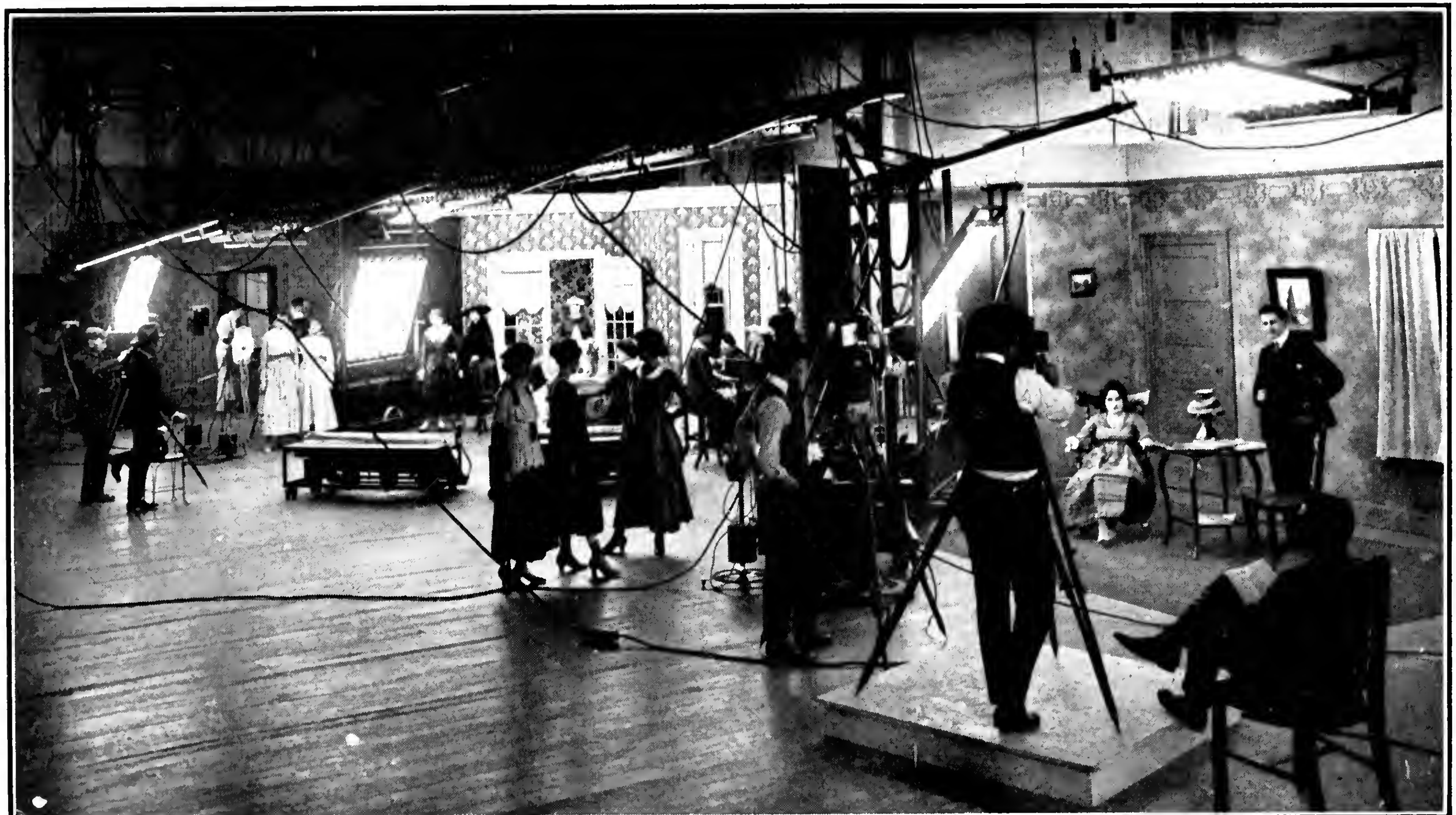
Besides being one of the fine arts, the moving picture art has become the greatest educational institution in the world. Very special lighting is needed for scientific films, for ultra-rapid moving picture work and for the several new color processes.

The moving picture industry is one of our foremost industries. Since Edison's and Jenkin's invention of moving picture devices of only a score or so years ago, the industry has leaped to fourth place in the United States. There is spent annually three or four hundred million dollars by the people here for admission to moving picture theatres. The daily attendance is said to average between ten and twenty millions of people. Of the fifty thousand motion picture houses in the world, there are about twenty thousand in the United States and the United States is the greatest producing center in the world. The sunshine of California has built up a major producing center in and near Los Angeles. There over twelve million dollars are spent annually for this production and about twenty-five thousand people are employed.

The importance of light in relation to expense of production may be judged from the following statement made by Mr. G. McL. Baynes of the English Hepworth Manufacturing Company. "As to photographic difficulties encountered in outdoor work in England, it is ridiculous to say that they cannot make pictures there. It is true production is more expensive, perhaps *twice* as much, because we have to wait for the sunshine." Thus in foggy England, the difficulties are much greater on account of poor light than in the West or East of the United States.

The invention of the high average white flame arc lamps and carbons and of other artificial light sources such as the daylight gas filled tungsten lamps and the mercury arc lamps, have eliminated these expensive waits for sunshine.

The home-center of the moving picture industry in the East is



*(Courtesy of Rothacker Film Company)*

MULTIPLE SET STUDIO.

again building up rapidly. There new studios are to be found, especially in or near New York City and to a lesser degree near other centers of population, in Chicago, Philadelphia, Cleveland. Scenic interest is another industrial factor which accounts for their location in Ithaca and Florida.

The increase in artificial light facilities has been an important economic factor in this Eastern movement which is being accelerated by the continual increase in the extraordinary salaries which are paid moving picture artists. The cost of production of an average negative of one reel is said to be about $1,000,

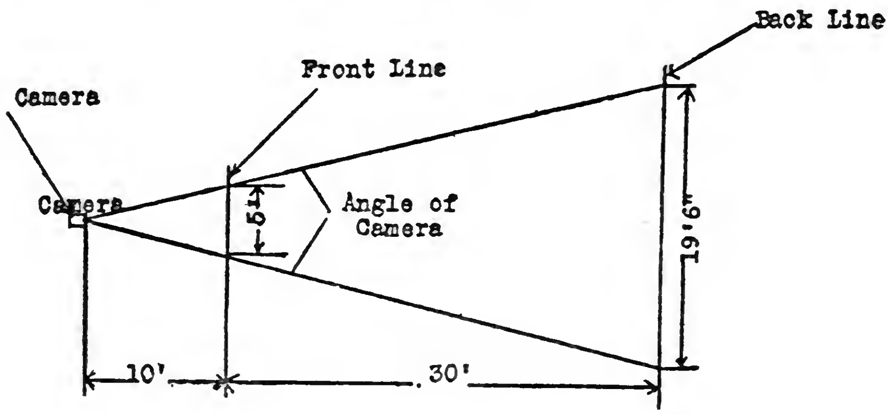



Fig. 43

Plan of Moving Picture Stage showing increased depth of Back-Ground.

and of this it is certainly economy to spend one or two per cent. on securing the best lighting.

The lighting differences between the theatre stage and movie stage are illustrated by Fig. 44 which shows the theatre stage has a broad front line, below which come the footlights and a very shallow background, because the essential action of the stage must be visible to every one in the audience on both sides of the auditorium. On the other hand, the moving picture photographer can select any point of view and this necessarily has an enlarging background in the usual case of real scenery. The camera lines in the ground view (Fig. 43) represent limits outside which the lighting units must be placed, except for trick flame lamps used to imitate lanterns and house lamps. In the vertical plane exactly the same rule must be followed in regard to increasing light of overhead lamps for the background. The excellent results from footlights has not yet been appreciated by moving picture artists.

Motion pictures became commercially successful for entertainments only when it became possible to select a subject, stage it with all the startling realism of the spoken drama and give its photography those qualities perhaps best connoted by the term, "portraiture."

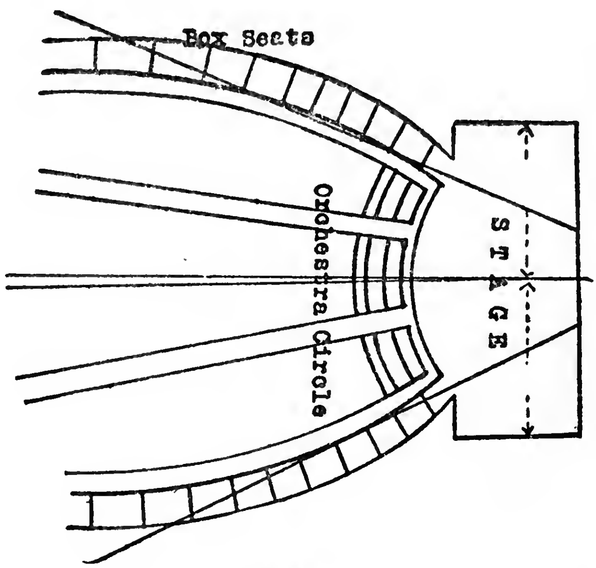



**Fig. 44**

Floor plan showing theatre stage is very shallow, and has a decreasing width of Back-Ground.

For portraiture effects—Rembrandt, line lighting, etc., control of the *position, direction* and *diffusion* of light is necessary. Some lighting forming an oblique angle on the face to the camera gives increased reflection and aids in preventing flatness. For artistic results, the white flame arc is distinctly superior for securing modeling, atmosphere, definition, half-tone and fine photographic quality in the negatives.

Mr. Max Mayers, in his valuable paper on "Artificial Light in the Motion Picture Studio," given before the Society of Motion Picture Engineers, says, "Back lighting is a splendid way of obtaining pleasing and natural results. This is effected by placing the lights well back and directing them *toward* but not *at* the camera, masking the direct rays at the lamp, and preferably using a shielding tube with perfectly dull black interior over the lens barrel, to prevent halation. Thus the figures and objects in the set will be silhouetted, and by the proper front arrangement of reflecting surfaces and well diffused lights at a fair distance, the features and details may be perfectly modeled in shadow, with pleasing highlight relief effected by the rear lights."

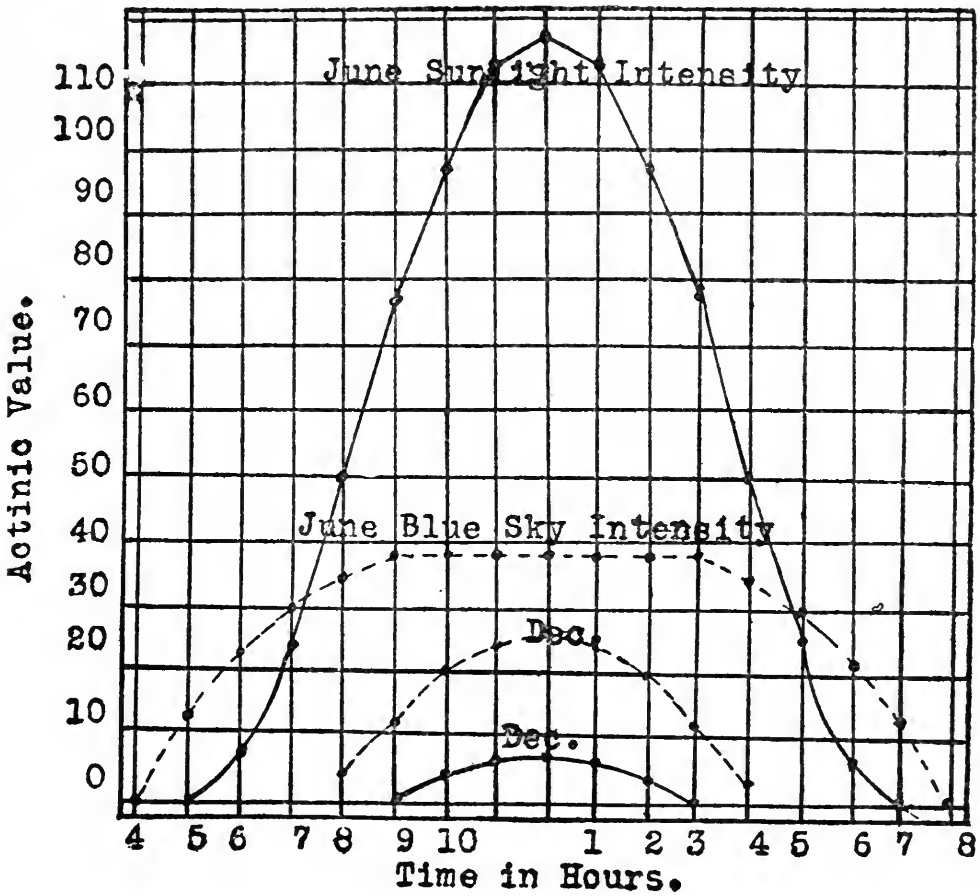



Fig. 45

Average daily variation for June and December.

A large amount of light is required in moving picture work, because of the short exposures (1/30 to 1/50 sec.) and need for definition. In the interest of definition and depth of focus it is highly desirable to work at small lens opening. For instance, with the white flame arc lights f 5.6 is often used in moving picture studios whereas f 4.5 and even f 3.5 have been recommended with other sources of artificial light. Some of the flame lamps, with their reflectors and diffusing screens, can be used to give a light intensity of 10,000 and more candles per square foot, so that even daylight is surpassed, if so desired.

We will now consider daylight. The larger the number of days of good, clear sunshine, the lower is the cost of moving picture production, because of the saving of time of high salaried artists. But little has been done as yet to use artificial light in conjunction with outdoor scenes for which daylight is ideal except for the interruption of the photography by dark, cloudy days. In England some use of arc lamps has been made for outdoor scenes. Even on consecutive clear days there may be a large variation in actinic light as shown in Fig. 45.

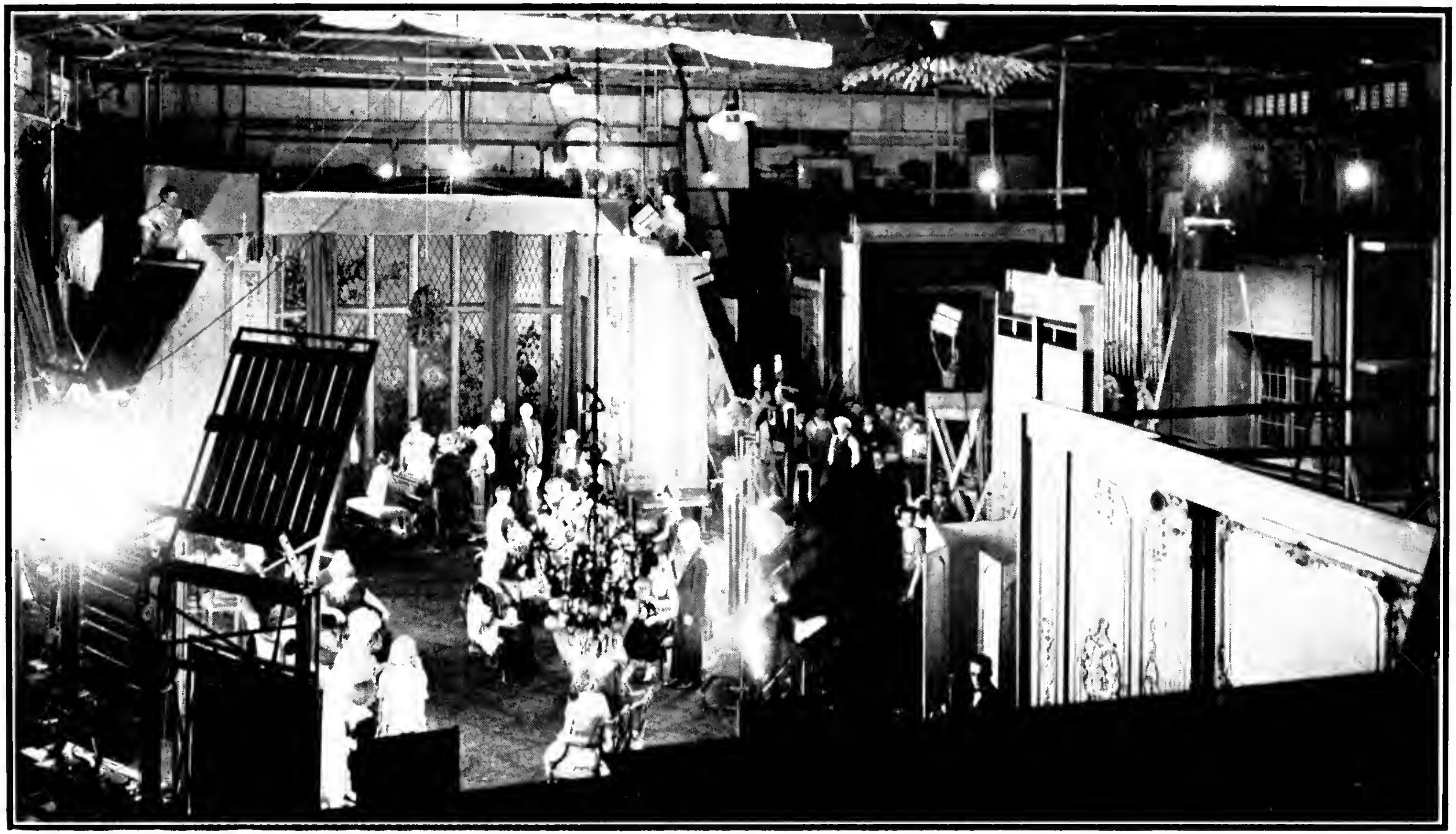
For interior scenes daylight must be diffused to avoid outdoor appearances caused by the direct shadows from sunlight. This diffusion is secured by using prism glass in the roof and sides of studios. If the studio work for interior scenes is done outdoors then awnings of light-sheeting or muslin are used to secure proper diffusion. This is sometimes done in studios with glass roofs, especially if clear glass has been used.

A serious objection to daylight in such studios is the hot-house effect, especially in summer. As these glass houses receive continuously one to two-horsepower of solar energy per square yard of projected area normal to the light, the heating effect is many times greater than with good artificial light alone, because the full amount of artificial light is used intermittently and seldom for more than a total of an hour a day.

The artificial light, used generally for side illumination, with daylight should be given by the light of the greatest photographic power in proportion to the energy liberated in the studio. For this reason flame arcs are commonly used with daylight. In the winter daylight is rather poor after penetrating the glass and screening and so dependence is then largely placed on artificial light.

This seasonal variation and hourly variation of sunlight and skylight is shown in Fig. 46, taken from Eder's Handbuch der Photographie. Again the changing direction of sunlight has been a serious objection and the studio, known as the Black Maria, of the Edison Company was arranged on wheels so that it could be moved to face the light.

Finally there is one class of interior scenes for which daylight



(*Courtesy of Famous Players-Lasky Company*)

Filming a scene in "The Career of Katherine Bush." There are no overhead lights in this set except such as come from the upper banks of the Cooper-Hewitt "Goose-Necks." Between the Cooper-Hewitt banks may be seen several Kleigel flood lights and at the back three spot-lights to give back lighting.

in any form is entirely unsatisfactory. This is in night scenes, where sharp shadows and brightly illuminated parts must come in the same picture. Again all moving picture work in actual interiors such as subways, mines, caves, hotels, theatres, churches, etc., must be done with artificial light. This brings us to the vital importance of artificial lights. And of these the closest to daylight photographically is the light of the white flame high amperage arc lamps.

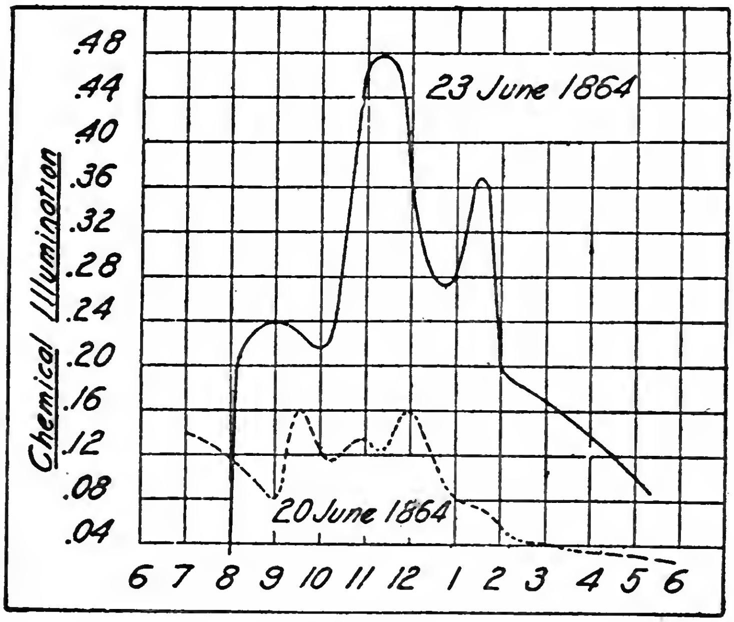



Fig. 46

Daily variation of photographic light with daylight.

The white flame high amperage arc gives a light which is remarkably close to daylight both in color and photographic values. Like daylight the spectrum is not entirely continuous, but the effect of being practically continuous is obtained by the enormous number of light giving lines in every part of the spectrum, including the ultra-violet which with the white flame arc is very similar to that given by sunlight.

This duplication of daylight is so good and the intensity of light is so great that this light is being used by large clothing concerns as a reliable substitute for daylight in making dye fading tests. In fifty hours of testing with the flame arc, dyes are faded to the same degree as by about three weeks of ordinary daylight in June in Cleveland. The white flame arc is also used for color matching.

It is a part of the higher management of moving picture producers to give the actors and actresses a background of reality and not of ghastly unreality. Producers favor the use of music to lend realism and to create a desired emotion. "The living interpreter must have the living scene to do his best."

It is now a recognized fact that pleasant scenes need pleasant light. White light is the best for ordinary drama and comedy. A blue or blue-green light is especially good for very sad scenes, such as death-bed scenes. Mr. Edward L. Simons at a time even before the use of flame arcs, pointed out the effect of blue-green light on the actors by saying "but without the arc lamp, it would be pretty hard to go through a real love scene, because everybody would look sick." Hence the value of the red content of the white light is of great importance to moving picture productions. Although photographically of no value for ordinary purposes, it is of value in giving the artists a suitable environment for their best artistic expression. When film is sensitized to long wave lengths then the red and yellow light are important.

A few hints here about "make-up." The moving picture artist soon learns that red will photograph black because the ordinary film is not sensitive to red light. For this reason the make-up should be light, little rouge being used. Gold teeth or fillings will photograph dark. An excessive amount of white clothing should be avoided as this may give rise to halation which results in a blur. Hence yellow, gray and other colors of clothes are used. This halation needs to be watched carefully with the lights having low latitude on plates. This means the picture will show parts highly lighted and dimly lighted with clear definition.

In regard to film sensitiveness the ordinary moving picture film has a maximum sensitiveness in the violet with considerable sensitiveness in the blue and ultra-violet and much less in the green and yellow and no sensitiveness in the red. Some moving picture laboratories are making orthochromatic films fairly sensitive to yellow light. For panchromatic photography and color photography, of course, all parts of the light are used. Because of the use of a yellow screen with these, special flame carbons can be used not only to give more light, but such light that a screen of better transparency can be used. This, of course, is very important because color photography film calls for a great deal more light for moving picture work than ordinary films. The yellow flame carbons with special screens have been found very good in motion picture production. Calcium fluoride is used and gives a spectrum rich in red and yellow bands with very little spectrum yellow.

The flame arc shows a rapid increase in actinic light with increase in current. In fact the flame arc with doubling of the current at the same arc voltage increases its photographic effect not twice but three to four times. This makes it profitable to use the flame arcs at high amperages of 15-25 to 35 amperes. In some cases much higher amperages have been used.

A vertical flame arc is generally preferred, but the arc will burn well in a great variety of positions. In general, flame upper carbons and flame lower carbons are used in moving picture flame lamps so that the lamps can be used on either direct or alternating current and without any regard to polarity if it is direct current. This arrangement is different from the photo-engraving field where a very common trim is a neutral enclosed arc upper carbon with a *white positive lower*. In this case the flame carbon must always be made positive because the flame chemicals travel through the arc stream from the positive crater to the negative crater. It is the flame materials that produce the light and wrong polarity or pure carbon open arc gives about one-sixth the photographic light of the white flame arc. However, a positive flame upper carbon gives better efficiency with a flame negative lower as against a neutral negative lower.

On alternating current, both carbons should be flame carbons, as here the flame material feeds from both electrodes, and so this arrangement gives the maximum efficiency. The use of reactance ballast on alternating current lamps in place of resistance ballast increases greatly the efficiency of a white flame arc for equal power in the arc, and gives from 50 to 100% more light for equal power on the line. With reactance ballast on two or three flame arcs in series on 110 volts, the overall power factor is better than .85. Three flame arcs in series on 100 volts with metal coated carbons give but very little if any more efficiency than two flame arms in series.

We will now consider some of the typical flame lamps used in moving picture studios.

Special flame lamps have been developed to operate on A. C. or D. C. and in series on 220 volts or in multiple on 110. This makes the lamp of universal use, and calls for no special attention to the electrical conditions. The resistance of the flame lamp to mechanical shocks, electrical shocks such as over-voltage and to bad weather conditions, has made it universally used for outside moving picture work. Combined with all these advantages is the remarkable small weight of these lamps. For instance some of the twin arc lamps weigh no more than 20 pounds for lights giving 8,000 or more horizontal candle power, and with the light of a little greater actinicity than daylight. The amount of light is probably greater in proportion to weight than any other artificial light used in moving picture studios. Further improved design can greatly reduce this weight.

We will now discuss briefly a number of typical high amperage flame lamps. The following flame lamps are commonly used: Allison and Hadaway, Aristo, Bogue, Chicago Stage Lamp, Joyce, Klieglight, Macbeth, Scott, Simplex, Sunlight, Universal and Wohl. As there is no article or book where these types have been shown collectively, no doubt the following will be of interest.

The Aristo lamp is an enclosed arc lamp which has been much used by portrait photographers and in motion picture studios. In the latter one frequently finds the Aristo lamps, white flame carbons ½ x 12 inches upper with ½ x 6 inches lower with or without the globe. The greater diffusion of the light and reliability of the flame arc immediately found great favor with the photographers of moving picture concerns when demonstrated a few years ago by Mr. A. D. Spear, at Edison Studio. The amount of light with 28-A and 63 arc volts with flame carbons was 5,130 mean spherical candlepower in the tests made.

The Allison and Hadaway lamp is a twin arc designed especially for portability in a suitcase form. There is also made by this company a diffusing cabinet with flame lamp and a small portable flame lamp with shunt control to greatly raise the current at the time of taking the pictures. The horizontal candlepower of the 15 ampere flame lamp is said to be 8,000.

The Chicago Stage lamp is unusual in having the flame carbons at right angles.

The Joyce flame arc lamp has been used somewhat in industrial motion picture work.

The Klieglight, Fig. 47, is a high amperage (30 to 40 amperes) lamp, with horizontal carbons. The lamp is mounted on a pedestal with casters, and is used for side lighting. The lamp is very powerful and so is usually diffused by a large glass screen. A low weight lamp with vertical flame carbons is also made. The portable Klieglight is shown in Fig. 48.

The Macbeth Company is well-known in the photo-engraving field, and have recently produced a tilting lamp, which is apparently of considerably greater efficiency than their usual photo-

Fig. 47
Klieglight Stand, 25-35 ampere with horizontal flame carbons.

engraving lamp. The lamp is designed so that the light can be directed to any part of the stage, both vertically and horizontally. The tilting lamp is designed to burn an A. C. and D. C. and in case of 220 volts, two in series.

The Scott lamp is a revival of the inclined gravity feed lamp at 15 to 20 amperes, and has two arcs in series in each lamp. This lamp is especially used for overhead lighting, and in a stand form for side lighting. These lamps give a greater effect by 40% than some of the flame arcs having only one arc on 110 volts.

The Simplex lamp is a twin flame lamp which is easily portable and can be carried around in a suitcase. This lamp is designed for 15 to 25 amperes.

The Universal or Majestic lamp has two flame arcs in series

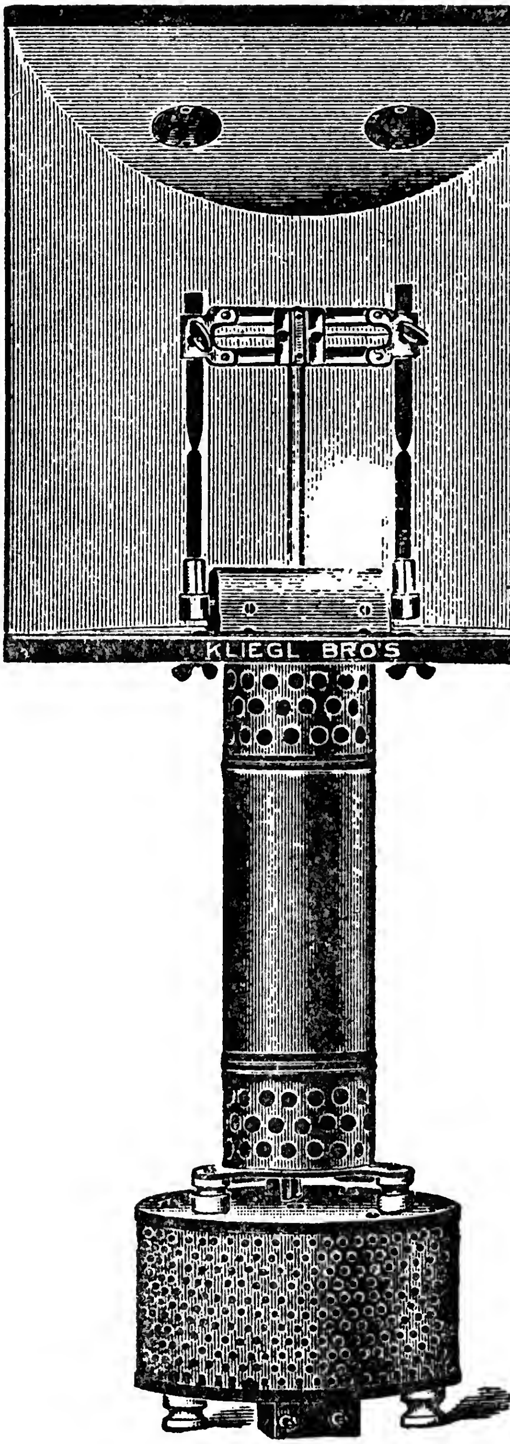



Fig. 48

Klieglight Portable.

and these are placed next to the economizer. The lamp can easily be directed to throw its light to any part of the stage.

The Wohl Duplex hanging lamp has two flame arcs in series and laboratory tests have shown a mean spherical candlepower of 6,700, with no reflector, with the lamp taking 30 amperes on 115 line volts (direct current). With the reflector, the horizontal beam candlepower is 22,000, according to tests made. In moving picture studios these lamps are provided with suitable woven glass diffusing screens or large tracing cloth diffusing screens. The Wohl Broadside is a stand lamp taking 30 amperes with four arcs in series on 220 volts or 60 amperes on 110 volt line with two pairs of series arcs. A portable light weight lamp is also made. A complete description of all the American lamps would fill a book, so we will pass on to foreign lamps and spot lamps.

The foreign makers of white flame lamps have lagged considerably behind the American manufacturers. An English flame lamp called Truelight, is interesting because four arcs are used in series on 220 volts, with the current reversing direction at each arc and carbons changing size to maintain a focusing effect. Some of the early German flame lamps are shown in Eder's Handbuch der Photographie. They can be of no importance compared with the American lamps.

Another type of flame lamp is the spotlight lamps operated usually by hand. These are used in the same way as the ordinary theatre spotlight lamps, but unlike the theatre lamps, the carbons used should be the white flame photographic carbons or the white flame searchlight carbons. Some movie directors have told the writer that using the white flame photographic carbon increased the photographic light about six times compared with ordinary projector carbons. The white A. C. projector carbon is not as efficient for studio lighting as the white flame photographic carbon.

The flame searchlight has also entered the moving picture field with great success. It is often operated fifty feet away, and with current 120 to 150 amperes. We will next consider home-made flame lamps. Electricians in moving picture studios have to continually devise new effects for simulating lanterns, indoor lamps, fires, etc. In general, it is a great mistake to make an article if it can be found on the market; but there are times when it is an advantage to know how to make a flame lamp out of other lamps.

For some purposes a cheap lamp with adjustable current for changing the amount of light is convenient. In Figs. 49 and 50 are shown the electrical arrangements that the writer devised several years ago for doing this. The globes should be removed

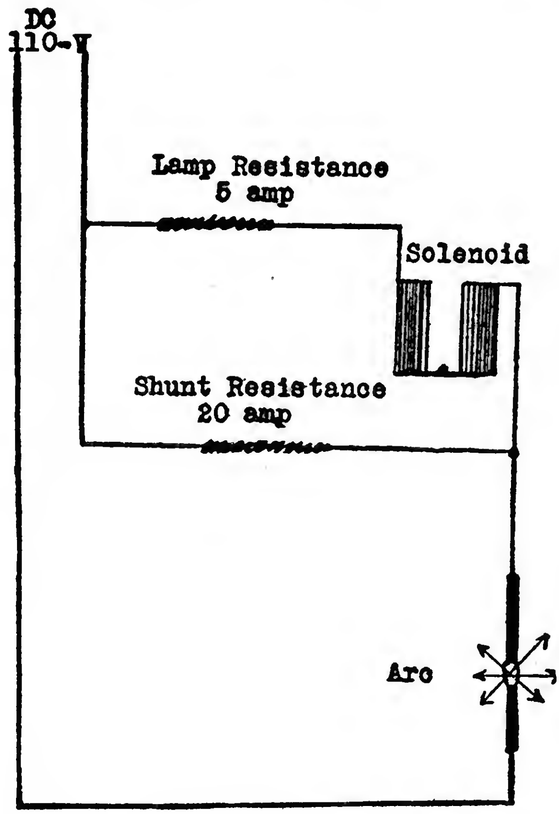
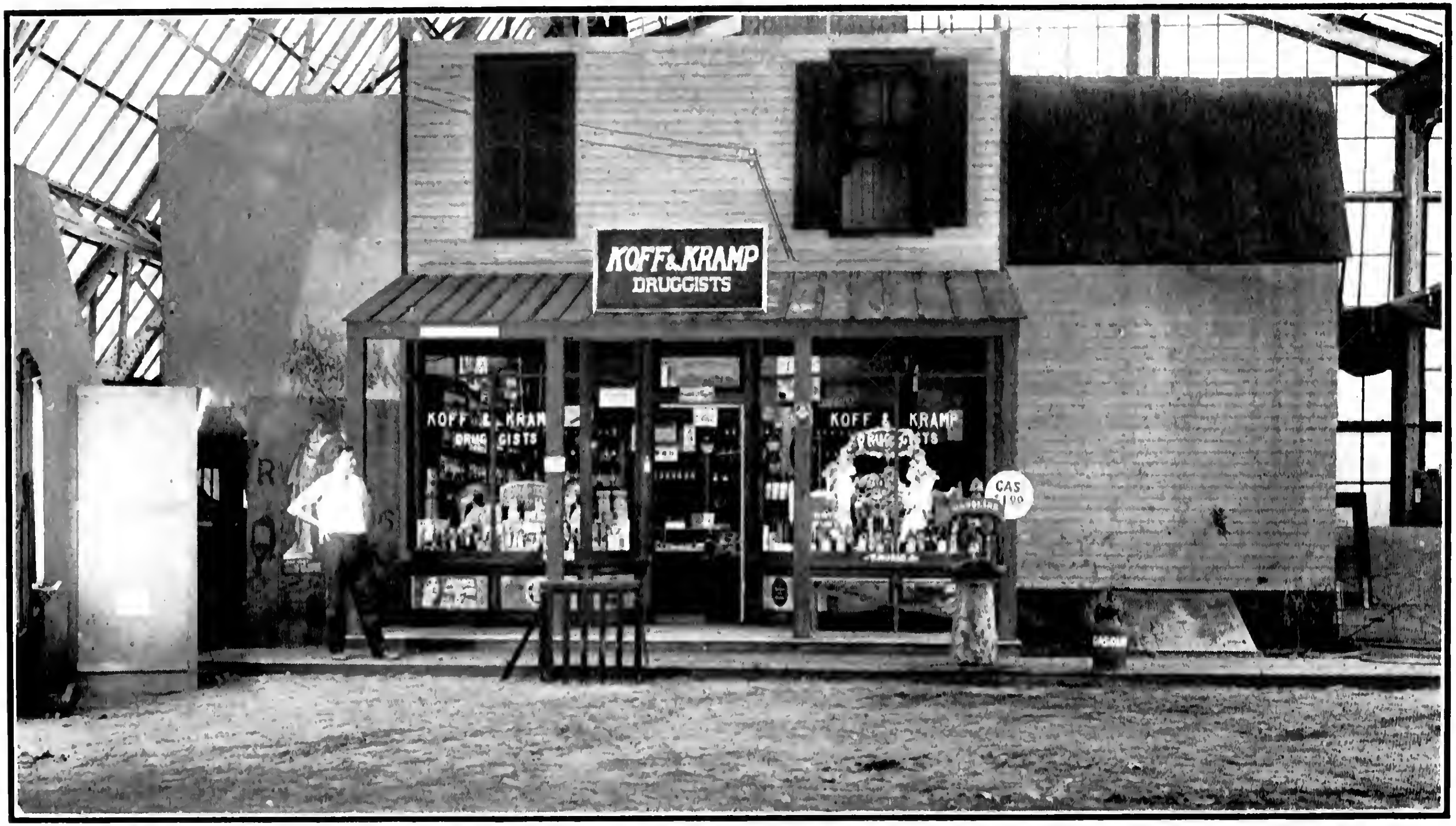



Fig. 49

Conversion diagram for changing D. C. Enclosed Arc Lamp to Adjustable Flame Lamp.

from the lamps and where necessary the lower holders should be made rigid. All the electrical wiring should be arranged on one side of the arc, and then a resistance (or reactance can also be used on A. C.) is connected in shunt to carry 15 to 20 amperes at 50 volts around the lamp resistance and solenoid ordinarily taking only 5 to 7½ amperes. Half-inch white flame carbons, metal coated at the holder ends, give excellent results. It is easy to work two converted enclosed arc lamps with the two flame arcs in series on 110 volts.




*(Courtesy Paramount-Arbuckle Comedies)*

AN EXTERIOR SET IN A STUDIO. DAYLIGHT BEING USED IN CONJUNCTION WITH ARTIFICIAL LIGHT.

The chief carbon used for photo-engraving and photography is the white flame carbon of which over a million a year are now being sold for this class of work. In the larger sizes a special star-shaped core is used. The color of the light can, where

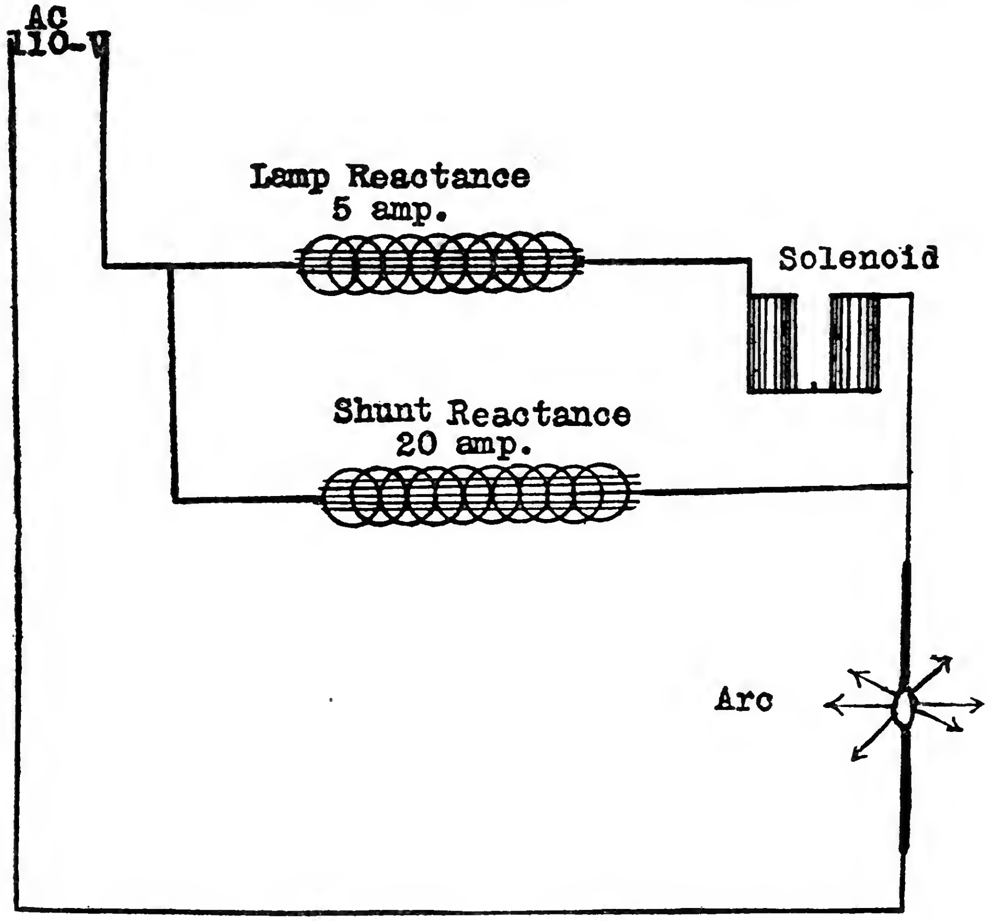



Fig. 50

Conversion diagram for changing alternating current Enclosed Arc Lamps to high amperage Flame Arcs by reactance shunt.

necessary, be changed to suit the exact requirements without buying a new lamp or even a new screen, because other flame carbons of different colors are available for these lamps when they are needed. The white flame is strictly a snow white light with a spectrum full of lines in its every part. This is most generally used.

The pearl white is a light a little more suited for panchromatic and color photography. The color of its light is very close to that of ordinary sunshine. The yellow flame carbon gives a light rich in red and green but having comparatively little spectrum yellow or blue. The sensation of yellow light is produced by the combination in the eye of the red and green light. The violet in this light is fairly strong. The red flame arc gives a light rich in red and spectrum yellow and has a fair amount of blue. The so-called blue flame carbons are designed to be especially rich in far ultra-violet beyond 3000 Angstrom units. This far ultra-violet is practically absent in sunlight and likewise in the white flame arcs ordinarily used in photographic work. The near ultra-violet light is very important photographically with sunlight and skylight, and with the white flame arcs. The ultra-violet of the white flame is largely in the region longer than 3500 Angstrom and it efficiently goes through ordinary glass.

An important improvement has been the use in photographic lamps of metal coated flame carbons, especially on the holder end. The metal coating reduces the holder drop in voltage from about half a volt to 1/20 of a volt so that a holder designed for 5 ampere use can, with metal coated carbons, be used at 20 or 30 amperes with long, excellent service.

American white flame carbons throughout the United States have shown 10 to 15 per cent better efficiency of light and longer life on the average than the foreign carbons. This is because of superior knowledge and skill that the American carbon manufacturers have as regards the making of these flame carbons. This condition of superiority has been maintained for several years.

The following ten points repeat a few of the advantages of the flame lamps for photographic artists; the greatest efficiency; best color duplicating daylight; instant response when current is turned on; less unsteadiness from fluctuating line voltage; wearing part of smallest cost per unit; most rugged to all kinds of mechanical and electrical abuse and to adverse weather conditions; lowest cost of installation and operation; can be used for spot lighting or with screen for diffuse lighting or with reflector for indirect lighting; largest candlepower per single unit and maximum portability in proportion to candlepower.

In considering the lighting of moving picture studios, we will consider first over-head lighting and then side lighting. In regard to overhead lighting there are two classes—diffuse and concentrated. The diffuse lighting is often obtained in the glass studios by use overhead of flame arcs which occupy only a small area and allow considerable of daylight to enter the scene. The concentrated overhead lighting is secured by mounting in a reflector a score of flame lamps or by the use of very powerful spot light or flame searchlight.

For side lighting powerful flame lamps on stands with wheels are universally used. A well-known illumination expert of mov-

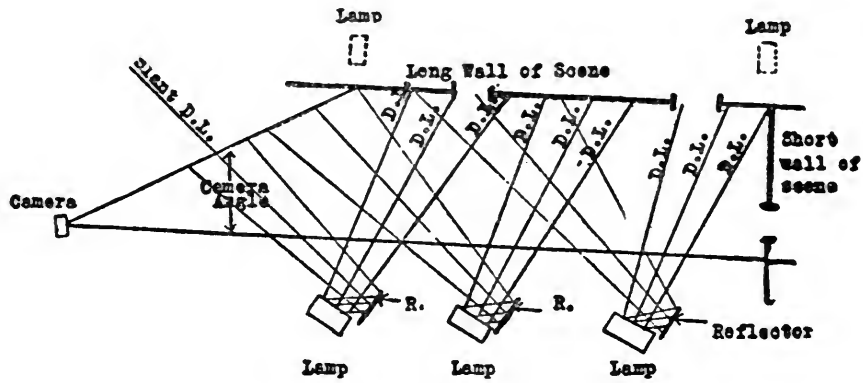



Fig. 51

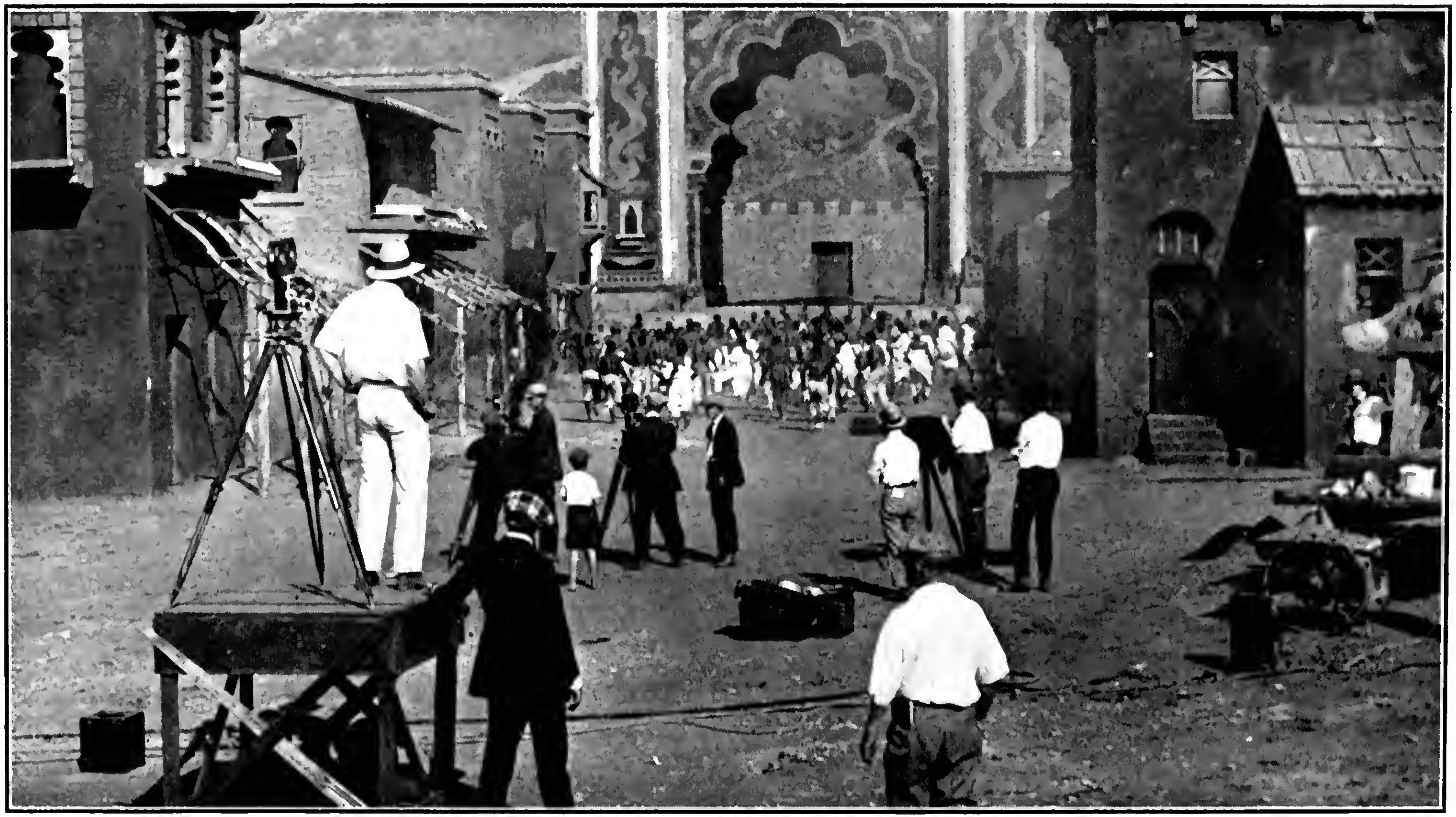
Typical side lighting for usual L scene

ing pictures, Mr. Mayer of Wohl & Company, states that the best lighting for moving picture stage is ordinarily given by using 50% more side lighting than top lighting, and that the so-called L arrangement (Fig. 51) is generally more effective for lighting than the box arrangement. The side lighting should have contrast to give the proper perspective. The angular sweep of the camera is usually such that the distance from the camera divided by two gives the width of the operating field (close-ups of 4 feet cover an approximate width of 2 feet).

The diagram, (Fig. 51), illustrates roughly, the L arrangement. In this arrangement there are shown the long wall of the scene to the short wall with the camera opposite the short wall and a number of side lights. The overhead lighting is not shown. Small reflectors are used with the side lamps to give slant light coming back toward the camera, but of course *not into it.* This gives a good reflection on surfaces sidewise to the light because the light is reflected so obliquely that a large amount is carried to the camera from side surfaces, and this arrangement gives the much desired line and Rembrandt effects, or as better known to the moving picture artist as molding and modeling effects. The working area of such a stage is therefore bounded by the long wall and short wall and the camera line, outside of which the lights must be. The distance outside should be sufficient to avoid harsh changes due to inverse square law.

The use of real scenery in place of painted scenery gives, of course, the best results. Real scenery should be lighted from the side. Painted scenery should be lighted directly from the front with the light striking nearly perpendicular. If the scene is set up with painted scenery, two sets of lighting should be used, one for the foreground and the other for the painted scenery. This same principle applies to panorama where near objects are lighted in one way and the panorama in a different way to give suitable blending of the illusion.

In lighting it is well to get a suitable blending of the direct light and of the diffuse light. Nature's rule is half and half. The diffuse light is so advantageous in cutting out the harsh, sharp black shadows and giving what is known technically as luminous shadow effects. Diffuse light can be secured by indirect light as well as by diffusing screens. The intensity of the light should photographically be very high in order to get the camera to operate satisfactorily with f 5.6. The flame arc can be used with a camera lens at f 5.6 to give good lighting on a small stage with 20 kw. The jump from f 5.6 to f 4.5 or even f 3.5 makes a big difference in the definition and clearness of the picture. The depth of focus can be maintained better, of course, with f 5.6, and because of the important artistic value of the background and the large distances with rapid movements that should be covered, it is highly desirable to work with a good depth of focus. With the flame arc the high concentration of light can be easily controlled as well as the direction of light. This convenience of control of the amount and direction of light are necessarily of the highest importance for free artistic expression on the part of the directing geniuses. In general, the moving picture stages will use with flame arcs the following amount of powers having the lens at f 5.6.



(*Courtesy of the Universal Film Company*)

"SHOOTING" A MOB SCENE.

| | | |
|---|---|---|
| Small stage....... | 20 kw. | 4 to 6 flame lamps |
| Medium stage ..... | 50 kw. | 10 to 16 flame lamps |
| Large stage ....... | 100 kw. | 20 to 32 flame lamps |

Using the larger openings of lens f 3.5 as low as 20 kw. with flame arcs can be used to secure the illumination of large stages. As the amount of light varies with the reflecting surfaces and is inversely as the square of the distance from the light sources it is not easy to give exact information without going into too elaborate detail. Also multiple reflection can in partly closed spaces greatly increase the illumination.

The artistry of the moving picture field is advancing so rapidly with so many new and complex changes that it is rather hard to keep track of even their main drift. Among the recent innovations has been the production of plays with the background subdued so that instead of the usual "close-up" the faces of the players in tense scenes are accented throughout the entire production of the play, as, for example, in the play "The Golden Change." In this case, the background is subdued to such an extent that the characters in the foreground appear to stand out in stereoscopic relief.

In another arrangement an intensely lighted background is used to cause the players to stand out in sharp shadow-like relief. In still other cases the immense control of intensity of light gives a power of securing the sudden appearance or disappearance of an actor in trick and dramatic pictures and to aid greatly in securing such peculiar effects as double exposure and other photographic tricks. The lighting can be utilized in such a way that the artistic forming of the picture is accented in harmony with the idea involved. Another way in which flame arcs are used is for casting shadows in trick pictures and to represent prison scenes in the more artistic manner of showing the shadows of the prison bars rather than the actual grim stolid fact.

It would not be expedient to describe in elaborate detail the many devices for rapidly moving the lights around in studios or the particular mechanical arrangement for carrying the lamps around on wheel cabinets or on trolleys or on ropes, etc. The actual installations of lighting are arranged in a great variety of ways. In some cases the overhead lighting is set up with the idea of permanently supplying the particular set. In other cases the overhead lighting is arranged so as to be easily moved by a trolley system from set to set. In the latter case the small weight of the flame lamps in proportion to their candlepower greatly reduces the cost of moving system and also affords a better utilization of admitting overhead daylight if this is desired.

For side lighting the flame lamps are mounted on wheel stands either separately or in powerful unit groups of 6 and 12. Such

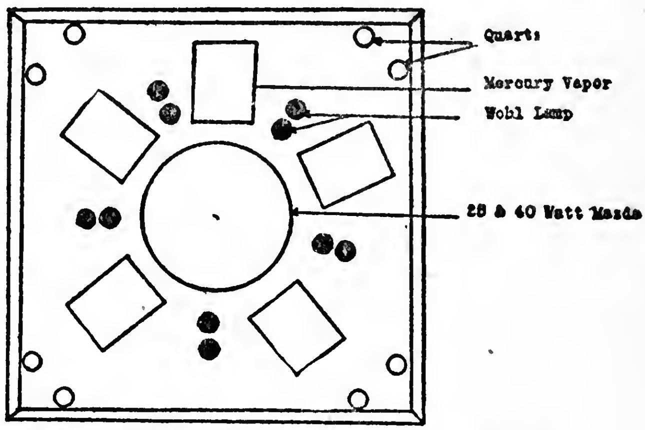



Diagram of the ring showing the approximate location of the Lighting units.
The large circle in the center represents a metal cone carrying 300 25 & 40 watt Mazda Lamps.

Fig. 52

Overhead lighting at Madison Square Garden for eight cameras simultaneously.

lamps are arranged to be easily moved. It is interesting to note that the resistance of the flame lamp can be mounted in a separate room so as to further reduce the heating which is remarkably small with the flame lamp. In some studios a dozen Aristo lamps are mounted in a portable cabinet formed in sets of three rows of four each with the top row forward and the bottom row back away from the stage. The whole can be easily moved around the studio because mounted on wheels.

We give a diagram (Fig. 52) of the overhead arrangement of flame arcs and mercury arcs used for lighting a boxing match at Madison Square Garden. It is interesting to note that eight moving picture cameras were used simultaneously and the entire room was so well lighted that brilliant illumination was obtained in every part of the large hall.

The use of flame arcs is carried out on an extensive scale in the Vitagraph moving picture studio located in Brooklyn, New York. Mr. Ross, master mechanic of that studio was kind enough to furnish data showing that the average number of flame lamps (20 amperes each lamp) used per set is twenty. In the Brooklyn studio alone, there are 225 flame arc lamps, hanging overhead, or in sets, in stands, or mounted so as to be easily moved about in small carriages in order to eliminate shadows.

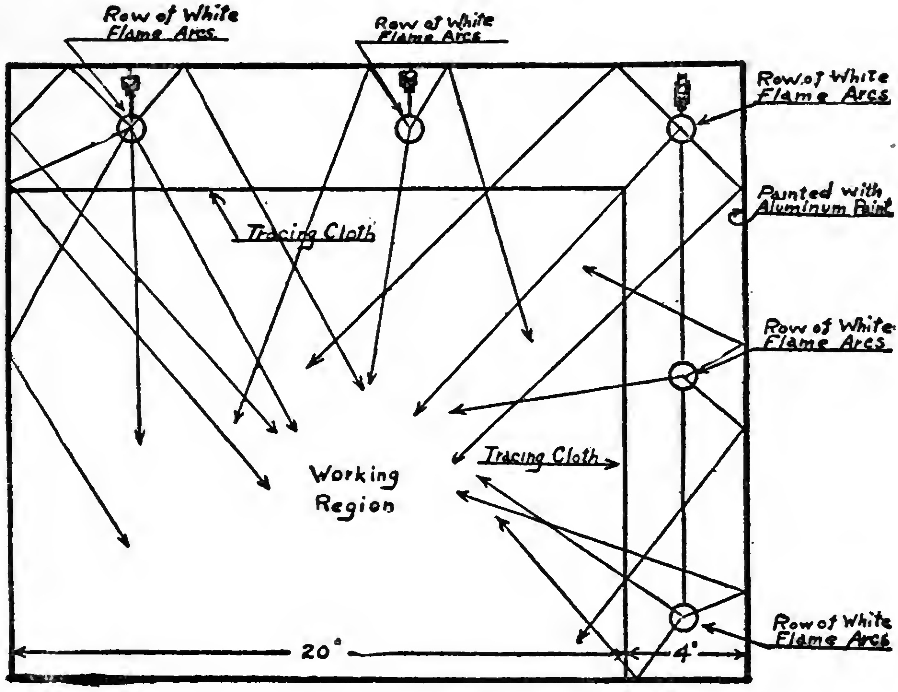



Fig. 53

Interior room with side and top diffuse lighting with Flame Arcs.

Figures 53, 54, 55, illustrate how some interior studios use multiple reflection to greatly increase efficiency and give diffused light.

Mr. Cecil B. DeMille, director of the Jesse L. Lasky Feature Play Company, wrote an article under the title "Lighting to a Photoplay is Like Music to Drama." He concludes that lighting effects as applied to motion pictures assume precisely the same value in the photo drama that music assumes in the spoken drama. He says "the theme of a picture should be carried in its photography." "The Cheat," representing unprincipled sinister Japanese characters, used abrupt bold light effects to definitely suggest the "clang" and smash of Japanese music.

In "Carmen," however, the Rembrandt idea was followed. The lighting and grouping of the characters in the soft shadows were all worked out in keeping with the school of that famous master.

"Light effects are out of place in comedy; there you will notice

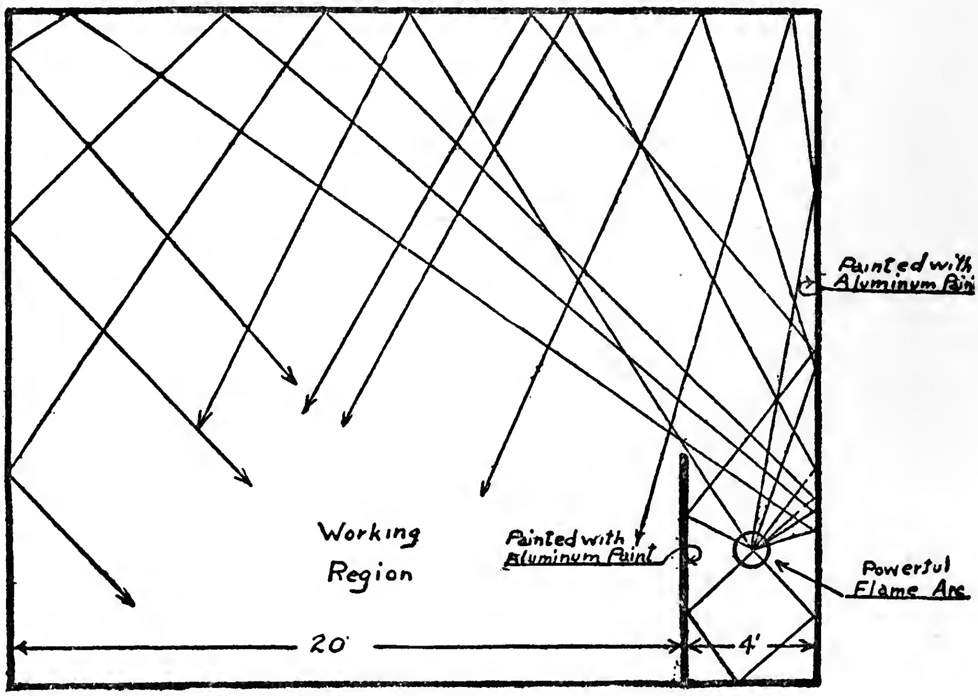



Fig. 54

Interior room with entirely indirect light with Flame Arcs.

our lighting is clear and brilliant corresponding to the faster light comedy and music, except in the melodramatic scenes where we carry our audience into thrills, not only by the action of the artist, but by a change in the mode of our photography."

Many new flame lamps have been invented and developed in the last year or two, and now varieties of flame carbons for special effects are available for a multitude of simple or complex artistic effects. However, only a small beginning has been made as to the artistic effects counting merely the minor factors of control such as direction of light, its diffusion, change of intensity and the power by proper color and environment to greatly aid the moving picture actor-artist.

(*Courtesy of the American Studios*)

THIS IS A CONSERVATORY SET DESIGNED AND CONSTRUCTED UNDER THE SUPERVISION OF S. A. BALDRIDGE, TECHNICAL DIRECTOR OF THE AMERICAN STUDIOS AT SANTA BARBARA. NOTE MANY DETAILS NECESSARY FOR DESIRED EFFECT.

There is the subject of "catch-lights" in the eyes of the players that represent the reflection of the light sources. If the light sources are rectangular in shape, then the catch-lights will be rectangular or triangular and with sharp curve points. The bad effect of not using round or oval light sources is easily appreciated. It is well recognized that curved lines convex to each other tend to give a sorrowful, depressed look. Curved lines

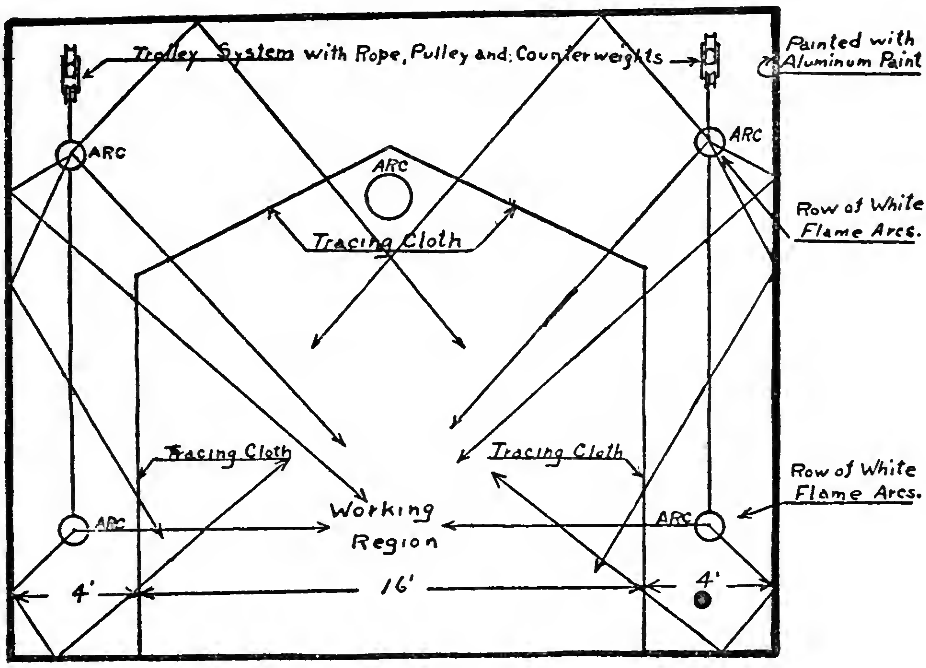



Fig. 55

Interior room for high efficiency lighting by multiple reflection.

concave to each other, tend to give a pleasant, agreeable, smiling look. By attention to the shape of the diffusing screen for the light sources, it would seem possible to vary this element so as to be in harmony with the ideals of the play. All the recent moving picture photo-plays of the best companies show the power of white flame arc lighting to give fine definition, splendid half-tones, luminous shadows and favorably shaped "catch" lights.

In some studios the light of the flame arc is thrown upon the ceiling or a reflecting screen, and in this way some very beautiful pictures have been photographed. The possibilities of indirect lighting with the flame arc have been touched upon. By suitable lamp design, it seems practical not only to get more diffuse light but also greater candlepower delivered to the working plane. Again in the matter of regulation, the shunt control is one of the important future developments that will enable the artists to secure a wide variety of new effects.

On alternating current efficiency can be greatly increased with the flame arc by re-actancy control.

In the matter of studio lighting, interior rooms lighted entirely by artificial light have splendid advantages, because the lighting can then be *entirely* controlled by the artist, and the extremely hot atmosphere of sunlight glass studio is done away with and a cool, comfortable studio can be maintained throughout the year. The director can then obtain all diffuse light, all direct light, or any proportion and direction of diffused and direct light under perfect control, and old King Sol with his changing position, will be entirely unnecessary for all interior scenes.

## Chapter XV

# EDUCATIONAL AND INDUSTRIAL PICTURE MAKING

THE making of so-called educational pictures has developed until it now calls for a high degree of specialization. Industrial pictures are of the same type in the majority of instances, and may be classed under the same heading as the higher grade of scenic pictures.

It is no longer possible for a cameraman to take his camera out in an automobile and, after riding around for a day, return with a heterogenous collection of scenes and dispose of it as "Picturesque Podunk," length 989 feet.

If he is not familiar with the region he is about to record, he goes to the nearest library or book store and peruses with care and diligence all possible literature describing the locality. He writes the history and location of landmarks and points of interest in his note-book. He records incidents of the customs and habits of the natives, with a view of finding characteristic bits to enliven the skeleton scenario which he will make before he starts to turn the crank on his picture. When he has done this, he engages a car and a chauffeur well acquainted with the locality, or pack mule, or whatever conveyance the case may demand, and a guide.

He then starts out with his outfit to find the things which he has noted in the synopsis. His eyes are open for anything that will add interest to the picture. Many things will greet his eye that he had not foreseen. But the chances are, if his scenario is what it should be, whatever he discovers will help round out and add interest or local color to what he has already planned. Oftentimes he discovers something that will give him material for another picture aside from the one he has planned.

I remember, making a picture of an historic Mexican city years ago. It nestles in a beautiful valley between high mountains of impressive grandeur, and my first thought was only of the beautiful scenic picture that I could make in the quaint old city, with its historic buildings and rugged mountain scenery. It was a perfect mine of interest.

When I had finished I had material for the following pictures, varying in length from 400 to 1,000 feet: "Picturesque Monterey," "Hemp Industry," "Rope Making," "Thermal Baths of Topo Chico," "Where Nature Makes Soda Waters," "Iron Industry in Mexico," "Zinc Mining and Refining," "Primitive Laundries," "Beer Brewing," "Mexican Cookery," "Bull Fighting in Mexico," "Pulque and Mescal—The Mexican National Drinks," "Beasts of Burden in Old Mexico," and some others which I do not recall.

On the first trip many of the scenes mapped out can be found and taken. Others will either be impractical, or lacking in interest, or be in such relation to the light as to require taking at a different time of day.

A compass and timepiece are indispensable, although in the absence of a compass the watch may serve for both. Point the hour hand of the watch in the direction of the sun and half way between the hour hand and the numeral twelve will be south. Knowing this and reversing the process will show you at just what hour the sun will be at the most advantageous position for taking your picture.

Make a note of each subject which you intend to take at a particular time and arrange the schedule with your guide so as to return and cover the missing scenes with the greatest efficiency.

Learn to use just enough film to show your subject plainly and well, but stop before the interest can lag. A naturalist friend of mine took a camera on one of his expeditions.. On the first trip he took a whole roll and sometimes two or three rolls of film on each subject, unless it flew away while he was reloading. Of the details of camp life, of the ex-president who was a member of the expedition for a portion of the time, of the methods of preserving specimens and a thousand other interesting details he took not one inch. They were every-day matters to him, and it never occurred to him that the people who would view the picture would be interested in anything other but what interested him.

Try to look at things with the eye of a curious stranger. Don't let the little interesting things that may be familiar to you get by. Often they are the spice which seasons the picture. A cute kid with a dirty face engaged in some childish occupation, or a baby animal of almost any kind, are more apt to touch the emotions of an audience than a beautiful landscape. The innocent flirtation of a buxom peasant girl, or the foolish amorous smile of a hulking farmer boy, even a close-up of a beautiful wayside flower adorned with a honey bee, or brilliant butterfly will bring your spectators into more human relationship with a scenic picture.

There are millions of people in this broad land of ours who have never had the opportunity to travel. An old style scenic with panoramas of ancient ruins or old castles brings to them no more sense of reality than engravings of a fairy story in a book. Show among these ruins or castles, things which are kindred to the emotions which they experience and you establish a sympathetic bond which gives them a sensation of reality and relationship to the images on the screen.

While dwelling on the intimate touches that go to make interest in a picture we must not lose sight of another factor. That is the sense of the beautiful. "Artistic composition" sounds highbrow, but the lowliest of us have some innate sense of the artistic. The soddenest wretch who ever passed a nickel into a picture house ticket-window may be capable of catching his breath at the glory of a mountain sunset thrown on the screen though his intellect would prevent his putting into words the emotion that the picture caused.

The cameraman who makes interesting educational pictures is more than a photographer. He is an artist, an author, a director and a scholar.

As an artist he strives to make his pictures pleasing to the eye. He is not content with his natural gifts in that direction if he is ambitious. He studies books on art and composition when he has the opportunity (and in this day of free libraries and cheap printing there are none who have not the opportunity.)

As a scholar and author he studies the subjects which he makes, and complies a coherent and consecutive story before he starts his picture. In his brain must dwell a clear conception before he can crystallize it for others.

As a director he has charge of his subject matter, and, whether his actors be moths or machines, cascades or cocoons, he is as surely the director as the man who moves the living pawns and knights on the chess-board of melodrama.

As a photographer and cameraman he is master of the camera's technique. Beside all the accouterments and paraphernalia of the studio cameraman he calls to his aid other devices, such as the microscope and the ultra-speed camera. He should have a large assortment of lenses of different focal lengths. He pictures phenomena so that he who runs may see and understand. The bullet's swift flight and a tree's slow growth; the mountain's magnitude and the microbe's minuteness slow down or speed up, contract or enlarge at his word of command.

With ray screens and panchromatic film he can accentuate or suppress or record with proper tone values the different colors as they appear to the eye.

The European war has aroused the American public to a greater interest than ever before in the slogan "See America First." Motion pictures, following public interest in the past, have shown the scenic wonders of the old world, the equatorial depths of darkest Africa and the fronded palms of southern seas almost to the exclusion of the many wonders encompassed by our own boundaries. True, we have seen a few excellent pictures of our best known scenic wonders such as Yellowstone Park, Yosemite Valley, Niagara Falls, Grand Canyon and Glacier National Park, but even their possibilities have been but touched.

How many of the thousands of visitors to Yellowstone Park have ever seen its indescribable beauties when wrapped in the mantle of hoary winter? The gorgeous spectacles of its boiling geysers driving back the ever encroaching ermine cloak of drifting snow; its trees bedecked with prismatic ice jewels from the condensing vapors; its sledges and teams of husky dogs and snowshoed drivers? Have these been caught on the fleeting film?

Where are the pictures of Alaska, that vast treasure house of which we know so little? Where is the cinematographer to record the customs and life of the Southwestern or Pueblo Indian as Curtis has done with the still camera? Where are the pictures of the romance of the new West where the cowboy has shucked his six-shooter, wears blue jean overalls instead of chaps, and irrigates his ranch and raises blooded cattle instead of Texas long horns?

Show us the pictures of the gigantic irrigation projects where the civil engineer has built mighty dams and created miracle gardens in the desert. Show us the life of the mining camps where machinery and resistless hydraulic streams wrest treasures from mother earth. Take us through the Philippines, let us see what a paternal government has done for the natives. Let us see the hospitals and schools, the railroads and highways our Government has built. What do we know of the Tagalogs, the Moros, the Bon Tocs, the Igorrotes and the other tribes? Are Luzon, Cebu, Mindoro, Negros, Samar, Mindanao brands of cigars or names of some of our island possessions? Show us the Maine Woods, the Michigan Forests, the commerce of the Great Lakes, the pulse of our inland waterways, the awakening of the new south, the Florida Everglades, the cities of the great Northwest, the Peoria distilleries and the Texas missions.

Surely the man with his hand on the camera crank who can select from a myriad of subjects the high lights and shadows of human interest and arrange them in logical sequence will be well repaid for his work and trouble. It is difficult to conceive of more interesting work than this; to take the things of interest in some particular place or on some particular subject and compose a graphic essay that will hold, if not a worldwide, a nationwide audience's attention.

Don't forget, if you take such pictures, that the little intimate touches of humanity and the close-up details of little things here and there are the master strokes that limn the greater subjects into high relief. Concretely, if you are photographing the awful chasm of the Grand Canyon, don't overlook the quizzical expression on the countenance of the quaint gray burro who patiently packs your apparatus, nor the horny toad that scurries away from beneath your feet, nor the round-faced papoose hanging contentedly to a limb while mamma squaw spins the wool for a zigzag patterned Navajo blanket; nor mamma squaw either. They all fit into the picture and make for what the artist calls "atmosphere" and "local color."

There are many avenues to money-making open for the amateur owner of a camera. It sometimes happens that the amateur beats the professional out on news events—generally because he happens to be on the ground first, but even when the odds are equal, the zest of the chase or happy circumstance has often favored the amateur with better records than the salaried professional. You may live where things of national interest do not often occur but that does not prevent your making arrangements with your local theaters to supply them with pictures depicting events of local interest.

As I have said before Percy Haughton, the Harvard Football coach, is making use of the motion pictures to find out what his teams are really doing. The motion camera is now a part of the athletic equipment at Cambridge, and it is expected that many hitherto inexplicable weaknesses may be found and corrected by a study of the film. The presence of the camera acts also as a stimulus to the men on the field, they feel that they are on dress parade; it may be possible to avoid the eye of the coach, but the lens is relentlessly sure.

Mr. Haughton took still photographs of plays that seemed perfect but which failed in execution. The difficulty that confronted him was human. Although the camera was fast enough no photographer could possibly tell the exact second at which to press the bulb. Had he known the second, it was impossible to co-ordinate eye and hand. The motion picture camera offered the solution. With a film the whole play might be taken and then the defect discovered by a study of the various pictures.

It was found that certain men shifted their poise just as the ball was being snapped, and thus lost their chance to start; that others relaxed their tension for just the fraction of a second before the play was on and thus were late. Individual peculiarities of the hands—a thousand and one little things that even the keenest eye could not find appeared on the screen when the negatives were studied one by one.

All our theories of activities are likely to be revamped as a result of the film studies. The eye cannot be trusted to tell what it sees, for it is easily confused by rapid motion. The leading trainers all believe that considerable progress in every branch of athletic activity will come about as a result of the opportunity to make a laboratory study of the human body in motion.

When it is realized that one-tenth of a second means about one yard in a hundred-yard dash, the importance of little things will be realized. The single faulty motion of the hurdler taking the bars makes all the difference between the fast man and the slow one. There have been men that could not really run fast in a flat race who were very speedy over the hurdles simply because they wasted no motion or effort in leaping across the obstruction.

It is in track sports that the greatest good is expected from the film—track performances are a matter of little things done

Making a Micro-cinematograph of Bacteria to illustrate a Biological subject at the N. Y. Institute of Photography.

perfectly. The day of great changes has passed; in the last fifteen years the style of athletes has been about universal. There seems little likelihood of revolutionary changes, such as the "crouching" start in the sprints or the substitution of the stride for the jump over the hurdles or the approach in the high jump. In many events the limit of human endeavor is near at hand, and the lowering of records will depend upon the conservation of effort toward the end desired. Nearly every big event is now taken with the motion camera and is eagerly studied by coach and athlete to learn if the winner had any new or improved way.

Authorities on the subject claim that baseball has been placed on a highly scientific basis by exhaustive investigations conducted on the same principles as the most efficient methods. It now seems probable that there are still greater possibilities for improvement under the keen eye of the camera.

Most of the education film companies have their own cameramen who attempt to cover as far as possible the more important educational features of this country. These traveling cameramen include in their itineraries the most interesting views of principal cities and the most beautiful views of natural scenery. It is impossible for the regular cameramen to obtain many important subjects so any motion picture camera operator will find a ready market for high class films.

For example, one of the largest and best-known educational film companies recently started a cameraman on a trip across the continent with instructions to take certain views in New York City before proceeding. He was told to obtain a view of the Statue of Liberty in New York Harbor with the sun setting behind the statue. Were it not for this particular fact the cameraman might have started on his way westward sooner but, owing to inclement weather and to the hazy atmosphere prevalent in the harbor, he had to wait nearly two weeks for the required picture.

How much better it would have been for the company to have sent their cameraman on and to have advised some local photographer just what was required. The local man could have been on hand daily at little expense.

There are in every fair sized city, some points of interest that make good educational subjects.

A man living in the small town of Burlington, New Jersey, was quite surprised to learn that an educational film company had sent a cameraman to that town to obtain some views of shad-fishing in the Delaware River. Shad-fishing in this particular spot had been going on for years and years but the local man had not appreciated the fact that this familiar industry would make a worth-while picture.

There is the same market for first-class educational pictures as there is for "Newsfilm." Educational work is best for the local photographer because there is no hurry, no mad rush because of the news-value of the picture. Often "Newsfilm" cameramen become excited and neglect to make some final adjustment of the camera which results in a spoiled picture. On the other hand, the man photographing educational pictures may take his time and get the best results obtainable.

Industries of special nature, such as the automobile industry, make good subjects. Beautiful scenery which you may see every day but which people may come miles to view, is well worth photographing. In fact any subject that is of general interest makes good material for educational pictures.

Of course, the more technical part of educational work, such as the microscopic studies of plants and small organisms cannot be attempted by everyone but some little feature might occur that would make interesting material for a picture that others would enjoy seeing.

A former professor of physics has taken up moving picture work lately. He found that photographs of some of his experiments in chemistry and physics were interesting and found a ready market. Now he is engaged in making a picture of the life and habits of the ordinary frog. You see there's always a field for those who are alive to the opportunity.

When the motion picture photographer goes from the temperate zone to the tropics he will find himself confronted by new problems, which result from the unhealthy climate, the uncertain light values, and the intense heat.

A cinematographer made a trip to the Canal Zone during the rainy season. When he removed the film from the packing cans it was soft and an hour after placing it in the box of the camera it was as wet as could be. The following morning it was completely covered with mildew. Moisture not only deteriorates the speed of film but, if the film is not developed immediately, destroys the latent image.

How may this be avoided? One cinematographer, working in the heart of Africa deemed it advisable to carry the film stock in a cooling case similar to a vacuum flask. He guarded against the exterior becoming hot by covering it with cool banana leaves. The film chest was made like a metal refrigerator of double walls of sheet zinc with layers of heat-insulating felt packed between the walls.

You who will travel in warm climates take my advice. Do not burden yourself with more film than you actually need as it deteriorates rapidly. If you can arrange to have small consignments despatched as required so much the better.

Before setting out, store the film in air-tight cans and place adhesive plaster around the edges of the lids. Once at your destination, select a dry and cool place for the film boxes. They will keep in good condition if placed in an ash-can or other air-tight receptacle in which a dish of fused calcium chloride has been placed. Calcium chloride has a strong affinity for moisture and takes it up rapidly. It absorbs it so rapidly that it will soon dissolve in the moisture it takes up, making a corrosive liquid disastrous to metal. Therefore, it should be surrounded by some absorbent material to prevent its spreading.

Re-load the camera only just before you plan to "shoot."

If you do not protect the camera from the direct sun as much as possible, you may experience considerable difficulty in turning the crank. The sun is apt to heat the brass and make it too hot to be operated with the bare hands.

Develop the film at the soonest possible moment.

A cameraman working in the Sudan discovered that sunrise is the ideal time for developing in the tropics. Then the air is not too warm and the water, kept in canvas buckets since the heat of the previous day, is cool.

This operator used an oblong straw hut, 17 feet by 11 feet, as a dark room. The inner lining to keep out the light was a red and black Turkey cloth, slightly smaller in size. No ventilation was provided. There were openings both at the top and the end to accommodate the wooden frames. In the openings were placed ruby glass, ground-glass, and thin wire netting. He made his own developing frame of native timber, shaped it like a 3-foot 6-inch drum and painted it with paraffin. He made two troughs, one for the developer and the other for hypo, of wood joining the sections together with pitch. He allowed for a space of an inch between the film and the trough interior. Each trough had two wings, so that the developer and hypo would be caught on falling from the film and be conveyed back into the trough-well. To hold the axle carrying the drum he equipped both of the troughs with slotted side arms.

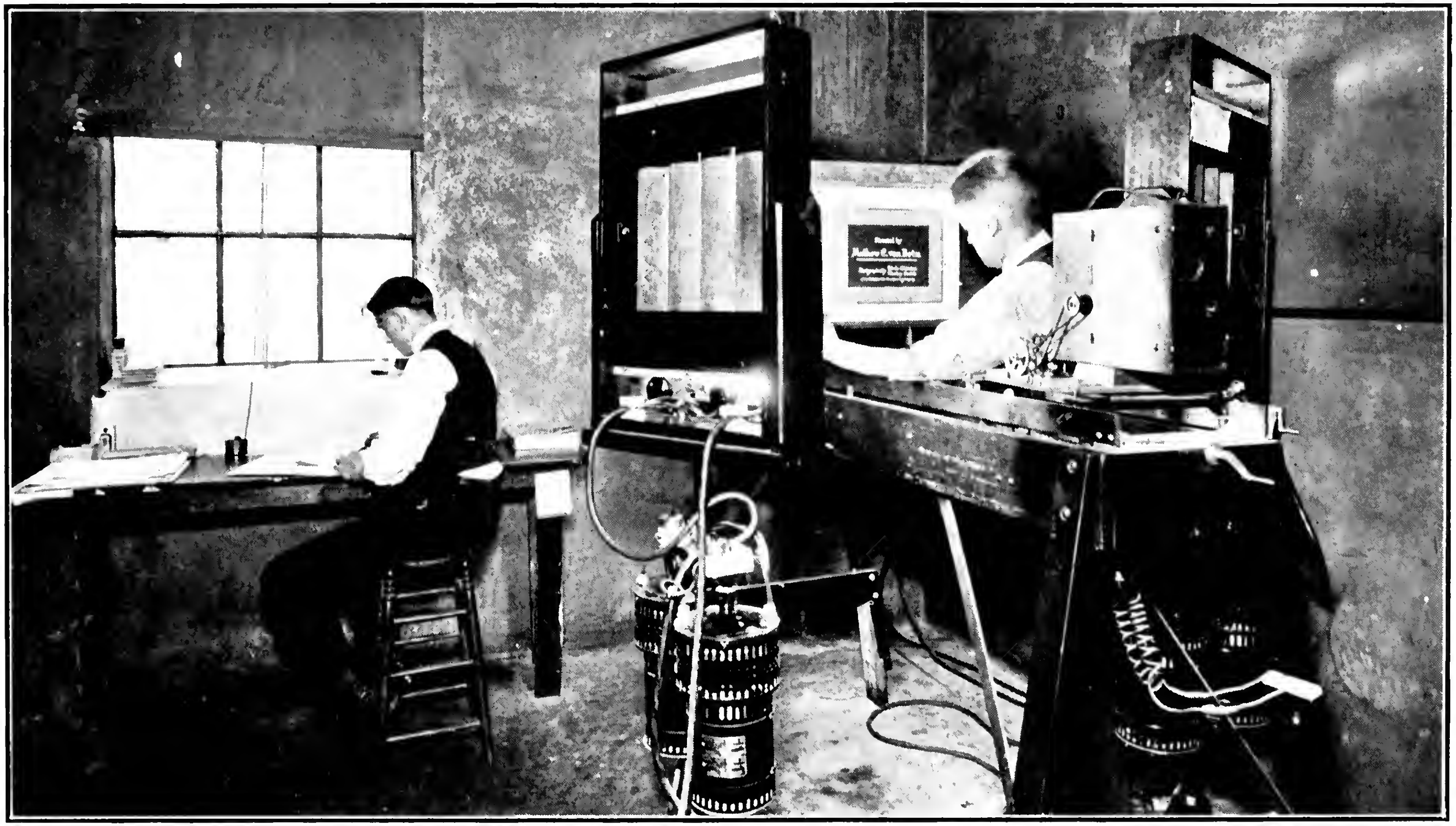
The developing materials used were Burroughs, Wellcome & Co. "tabloid" pyro soda and a little bromide of potassium. He used eight cartons to develop two hundred feet of film, and dissolved them in a bucket half filled with water.

Often water is difficult to get and of poor quality. I have used river water that looked like coffee by stirring an ounce of alum in a barrel of it and allowing it to settle over night. I used the clear water at the top by decanting it off with a short length of hose. Many times the residual sludge in the bottom was four inches deep. At a pinch, sea water may be used for washing if a final rinse of about five minutes be given in fresh water.

For the worker on a small scale, pin racks and trays that nest compactly are probably best on account of ease of transportation.

One man showed me a neat outfit he had made. It consisted of skelcton drums which could be dissembled for packing, with nesting nickel-lined metal troughs. The entire outfit of a dozen 100-foot drums, three troughs and a lot of black felt, used for extemporizing dark rooms from hotel rooms and native huts, packed into a fair-sized trunk!

He dried his films on the same drum on which they were developed, a thing which is difficult to do satisfactorily on pin frames.



*(Courtesy of Rothacker Film Company)*

PHOTOGRAPHING TITLES WITH MOTOR-DRIVEN CAMERA.

## Chapter XVI

## ANIMATED CARTOONS

IT is now several years since Winsor McKay, the famous cartoonist and creator of innumerable and popular comic characters, took the trouble to make sixteen thousand drawings, proving that with the system of reproduction used in cinematography to create the action in the images he could, for the first time in history, produce on the screen the miracle of an animated drawing.

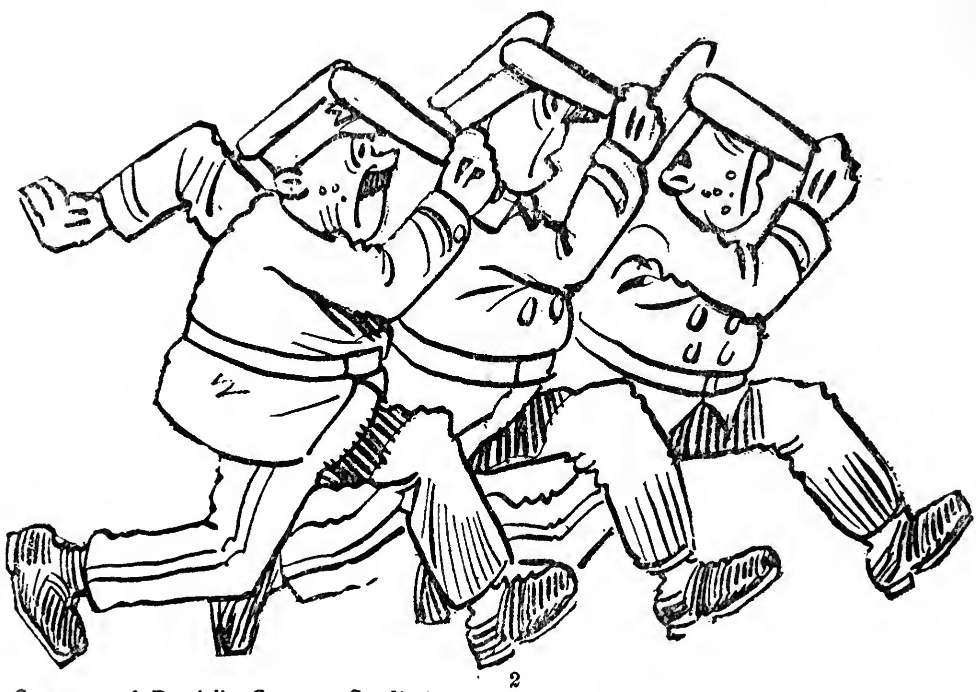
Animated drawings became immediately popular in Europe although not on the same scale or with the same effect as in this country. Profiting by the example set by McKay, others applied themselves to the same work and soon produced films with animated drawings, cartoons, caricatures and other products of the pen and brush which became so popular with people that they have come to form an indispensable part of cinema exhibitions.

Without a doubt, sixteen thousand drawings is a great number and not every one has the patience of McKay nor the skill and time to devote months and months to the production of one picture. As a result of this, the art has degenerated a bit, without losing any of its attraction, and still the inimitable creations of McKay and of Bray, who followed faithfully in his footsteps, have few imitators in point of technique, although animated cartoons continue to excite delight and applause.

The average person has little conception of the mechanics of animated cartooning. One need not wonder at this for many young artists are likewise ignorant. Those artists who are doing this work have perfected schemes of their own, after weeks and months of practice and experimenting. The successful ones jealously guard their system. The reasons are obvious.

As a rule, trick photography is combined with an intricate study of motion and its portrayal. Some artists rely almost entirely upon successive drawings and others upon cut-out figures—an elaborate and delicate process. Occasionally one will find an


1 and 3



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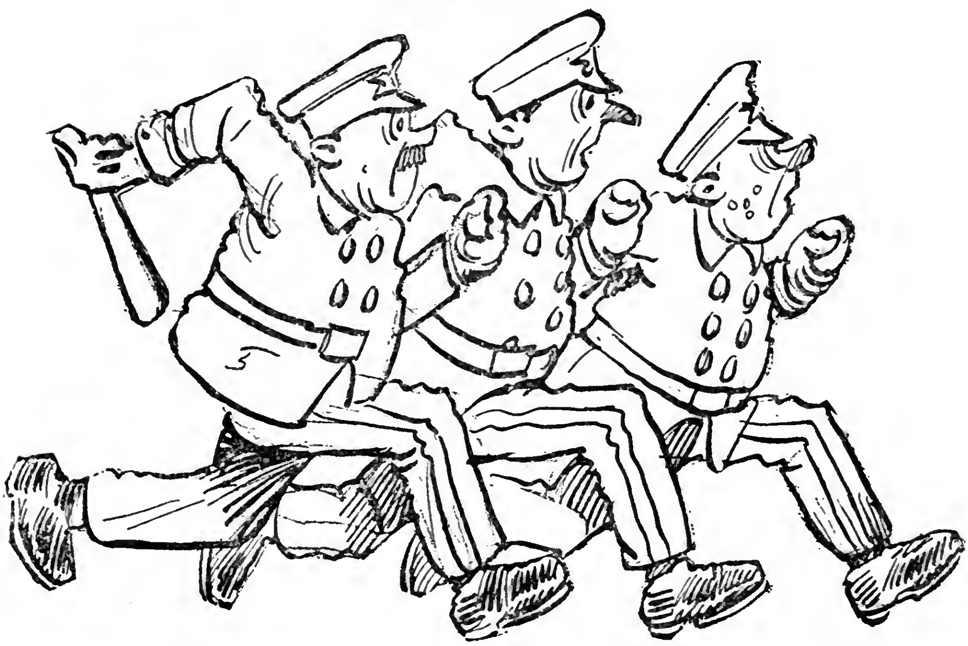
*Courtesy of Daniel's Cartoon Studios)*

The same silhouette is used for 1 and 3; again, the same silhouette is used for 4 and 6. By photographing 1, 2, 3, 4, 5, 6 in succession, the illusion is that of policemen running. This succession is repeated as many times as necessary

4 and 6



5

artist who makes as many as 5,000 drawings for each 500 feet of film. On the other hand, an ingenious artist might obtain smooth animation with but 500 drawings for the same length of film.

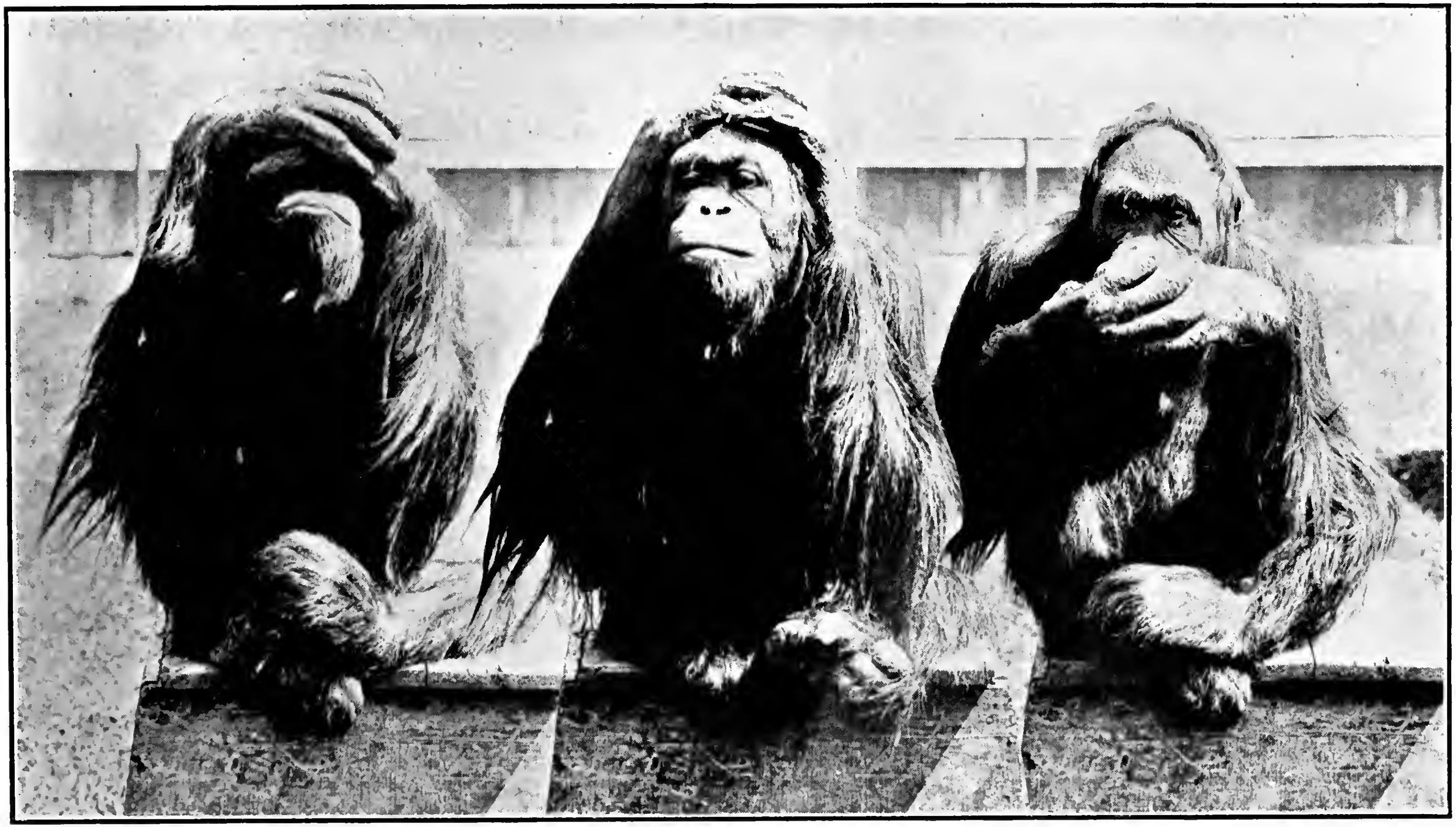
Consider the task presented when animal cartoons are drawn and the artist has to make four legs move in a fairly natural way and at uniform speed in bringing a dog or cat into a picture. If too many drawings are made, his picture drags; if too few, the motion is jerky and stiff. To strike the right combination is an art.

There is one difficulty which, while perfectly evident, is rarely appreciated. "*Minute exactness* is profoundly necessary in animated work," to quote Vincent Colby, creator of animated Colby Dogs, "for the excellent reason that the drawings are enlarged enormously when projected on the screen. This brings out in a glaring manner the most infinitesimal inaccuracies present in the original sketches. Thus the cartoonist's finished work for the movies contrasts with that of the newspaper caricaturist in that in one case the cartoon is enlarged and in the other, reduced for presentation."

In order to animate a cartoon, it must be drawn on some transparent medium whether it be paper, celluloid or ground glass. In the center of an ordinary bread board cut a rectangle 9" x 12". Fit a piece of window glass into this opening. Two steel pegs, four and one-half inches apart set into a bar five and one-half inches in length are fastened to the board at the upper side of rectangle and immediately at the edge of the opening. The bar must set in a chisseled-out space so that the surface of the bar is flush with the surface of the glass and board. The glass is held in place flush to the board by nailing thin strips of wood to the edges of the rectangle beneath. It is held fast by placing strips of adhesive tape around the edges of the glass.

The board is placed at a slight angle to the drawing table and an electric light is put under the glass. The paper used is substantial ledger paper free from water marks. The paper is held in place by punching holes at the top, four and one-half inches apart, which fit over the pegs in the peg-bar. Thin celluloid, a clear and transparent grade, about .005" in thickness is used over every drawing which goes under the camera.

Celluloid is one of the most important time-saving devices in



(*Courtesy Universal Film Mfg. Company*)

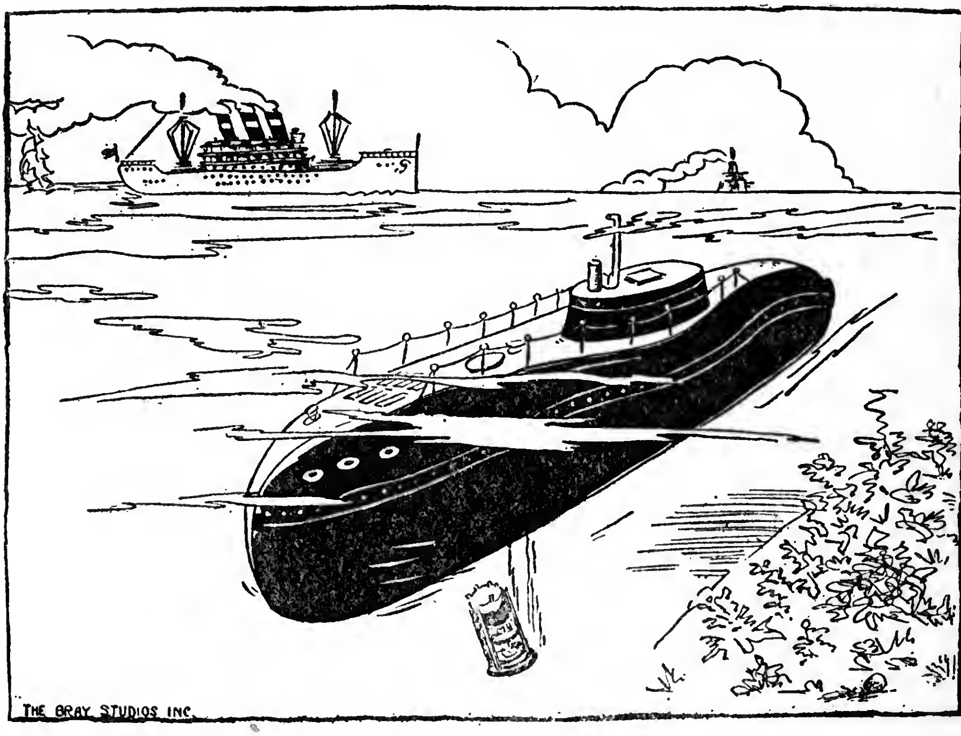
"SEE NO EVIL, HEAR NO EVIL, SPEAK NO EVIL"—A TRIPLE EXPOSURE OF JOE MARTIN.

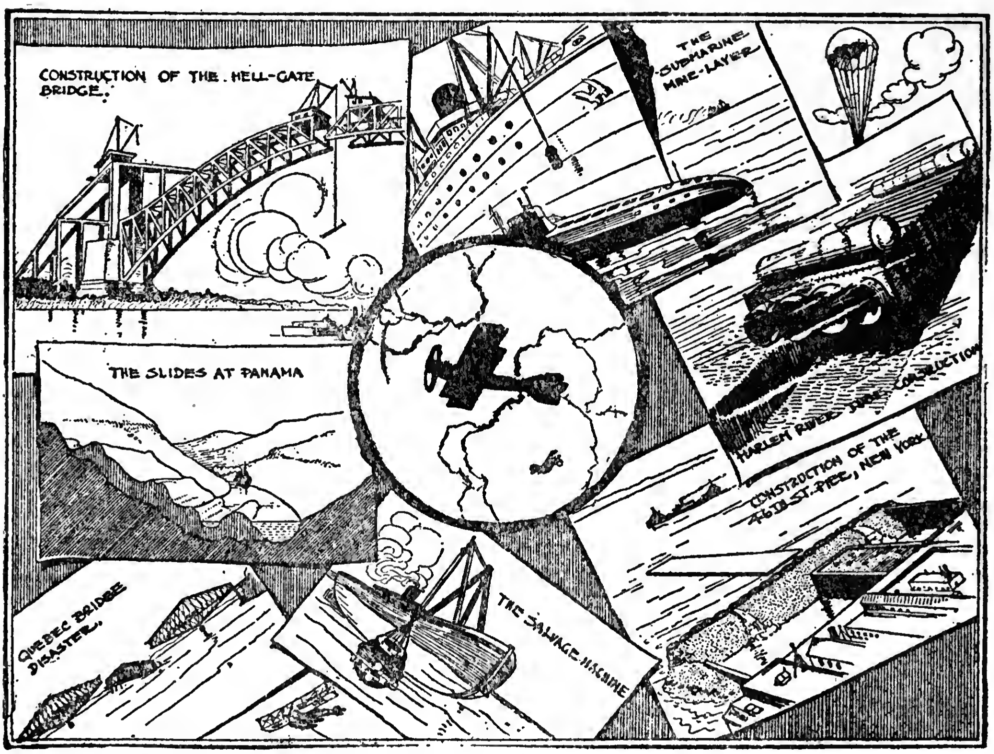
animating a cartoon. All drawings not representing motion may be put on celluloid. To be more explicit. Let us imagine a kitchen with a table in the middle of the room, on the table a jar of jam. A boy walks into the room, spies the jar, walks near the table, rubs his stomach in anticipation, takes the jar of jam and walks out of the room through the same door through which he entered. Those parts of the picture which remain stationary may be drawn on the celluloid. Make it a point to take care of as many things on the celluloid as possible. This leaves less to take care of on the paper drawings. In carrying out the action planned above, one would place a paper on the pins and, after drawing those lines which do not move throughout the action, on the celluloid, would place the celluloid face down on the model. Since the jar of jam is stationary for the first part of this example, the jar could be drawn on the back of the celluloid and left until that part of the action when the boy takes it up. Then it could be erased with ammonia.

Before attempting to animate a cartoon, an artist should observe all natural movements of man, animal, fish, automobile, train, or whatever it is he wishes to animate. He must likewise study the consecutive minor movements which go to make up any major movement: the positions of the feet in running or walking; of the hands in clapping, etc.

The field is the space inside of which all action must operate freely. The field lines should be ruled on the glass. 7″ x 9½″ is a good size for the field. All action entering the field should be started from behind the field lines.

In order to keep an exact likeness of a character throughout a picture it is best to make a complete set of head positions of that character. In this way, the head may be traced from the model by placing it under the paper in the position desired. This not only keeps the likeness the same but holds the proportion which is difficult to obtain free handed. The ordinary set of head models is drawn in a row on a slip of narrow paper. They are composed of five positions. One profile, one three-quarter front view, one three-quarter rear view, one full face and one full rear view make up the set. If any other position is called for, it too can be placed on the slip of paper and used as many times as required.




(*Bray Studios Inc.*)

SOME OF J. F. LEVENTHAL'S ANIMATED PICTOGRAPHS WHICH ARE OF A HIGHLY INSTRUCTIVE NATURE

### Cut-Outs

A cut-out is any object which is cut out of paper or celluloid and laid over the paper drawings or the celluloid overlay. Suppose a man's hat blows off his head and out of the picture. A drawing of the hat may be made of celluloid. The artist then cuts out the hat and instead of making separate drawings, moves the cut-out under the camera until it carries out the effect of being blown out of the field. Talk baloons are also cut-outs and are laid over the celluloid while the characters make mouth movements. ALL cut-outs must have the edges blacked or they will cast a shadow.

Ordinarily the action on each drawing should advance about one-quarter of an inch but sometimes more or less. In short action, where the space is limited, make a division for the moves and space the action each time, the distance of one of these divisions. In operating between two fixed points always make the divisions equi-distant for the moves. Fast action should never be spaced over three-quarters of an inch. Wider spacing makes the movement jumpy. The spacing of drawings does not govern their speed on the film. The number of exposures given each drawing regulates the action. The fewer the exposures the faster the action.

Avoid having more than one character or object in motion at the same time as the eye can follow but one movement easily. Characters should be brought into some natural and appropriate position before being kept idle for a long period. Such positions as thinking, sleeping or resting are frequently used. Any object or character whose part of the plot has been spent should be eliminated from the scene as quickly as possible.

When photographing take the top drawing by the lower right hand corner and lift and lower it rapidly so that one drawing can be seen then the other. As a result, the movement made by the two drawings can be seen. Do this frequently when penciling out the action and you will find it a great aid in obtaining perfect animation.

All tracing should be carefully done, line for line and dot for dot. Any carelessness will quickly be revealed in the enlargement on the screen. Models for tracing come from the figure or parts remaining idle and each tracing is made from the same

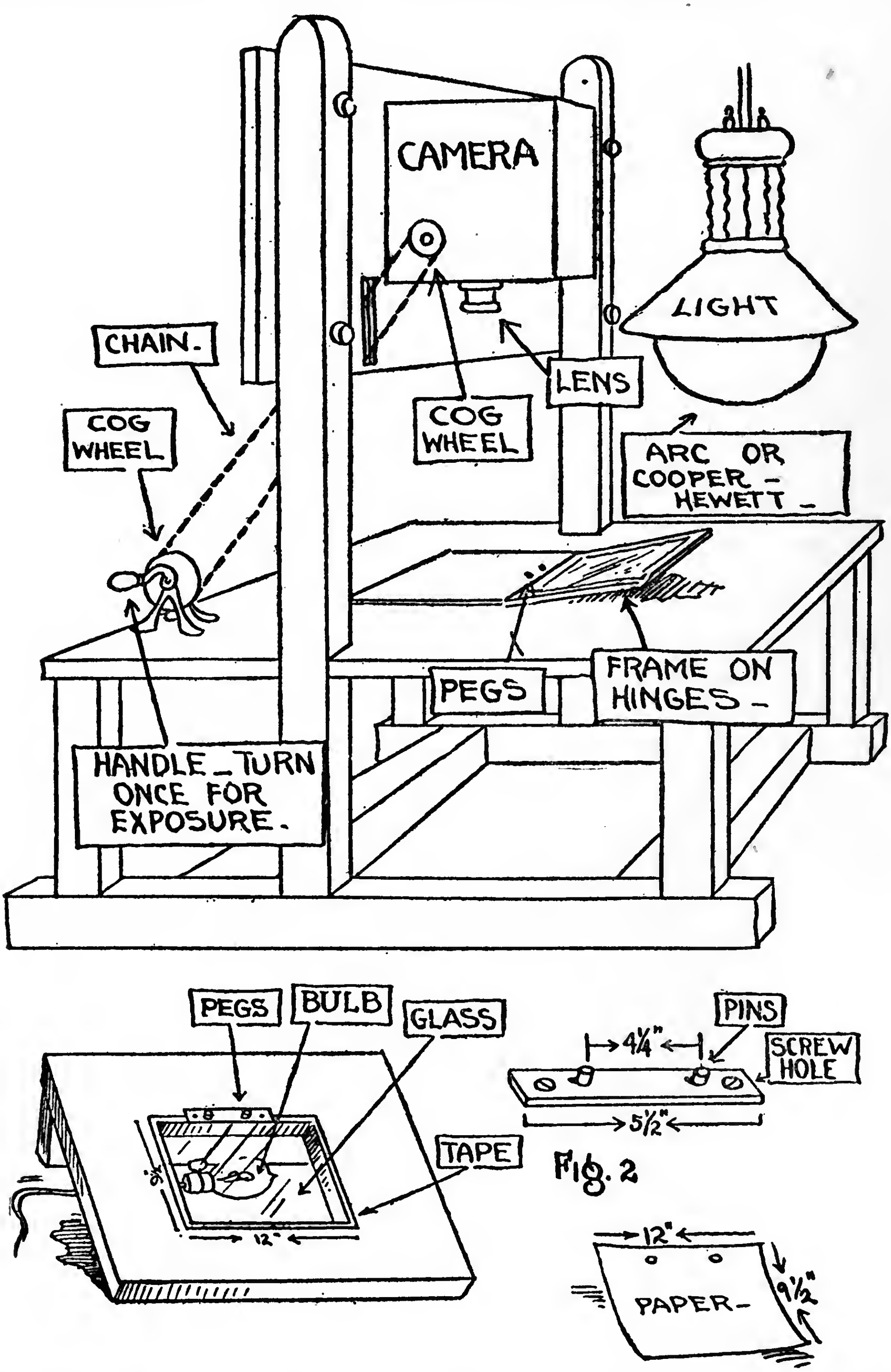



FIGURE SHOWING DETAILS OF THE CONSTRUCTION OF A CAMERA STAND FOR MAKING ANIMATED CARTOONS AND DIAGRAMS model until the figure takes another position which will serve as a new model. Traced lines should not wiggle in the slightest degree. You can test the accurateness of your line by flipping the paper. If the pen should move the least bit in following a line, scratch out the wrong line lightly with an ink eraser and correct it.

The parts to be traced on each drawing should be noted by a number in the spot where the tracing is to be made. The number used for the tracing note is the number used on the model. Jot notes describing incidents in the action outside the field lines on a drawing. This note making is especially valuable when making drawings which reverse or repeat actions.

One sketch-saving trick consists of making a drawing of a setting and having a large number of half-tone prints made of it. On these reproductions the motion is sketched in, thus saving an almost endless amount of work.

### To Photograph Animated Cartoons

The camera is set at a distance above the drawings so as to exactly cover the field of the drawings. A glass frame is fastened to a board and a peg-bar is set in this frame with pins to fit the holes in the paper. Each drawing and all celluloids for that particular scene are placed on the pins in order. The glass frame works on hinges and is lowered over each drawing and its celluloids holding them firm and flat. Arrange two nitrogen bulbs with reflectors so as to illuminate the drawings evenly. When one drawing has been photographed, the next one is put in place.

As I have said, the fewer the exposures the faster the action. Ordinary action is given three exposures. Fast action is given two exposures and rapid action is given but one exposure per drawing. As exposures govern speed, it is advisable to organize a system for walking, running, jumping, etc., and fix an exposure scale to operate action. There is no rule for exposures, they must be regulated according to the artist's judgment.

Each paper drawing must be numbered and each scene designated. Also prepare an "exposure sheet" on which the exposure of each scene must be indicated.

There is a great demand for animated cartoons. It is perhaps best for the amateur to confine his efforts to short bits of film made especially for advertising purposes.

A number of large concerns market animated cartoons. In such a place the amateur can find employment. The artists who animate the cartoons earn as much as a hundred dollars a week, their rating depending upon the amount of footage they are capable of turning out each week. Those who work on celluloids or at tracing earn less, but have every opportunity to study and advance.

## Chapter XVII

# TRICK-WORK AND DOUBLE EXPOSURE

UNDER this heading will be handled the numerous so called "fake" methods used to deceive the eye into believing it sees something which really never occurred, and, also some of the methods used to embellish or aid in the artistic conception of the picture.

The director will often require that the picture grow darker and darker gradually until it has "faded" to blackness. This is called a "fade-out." It is supposed to indicate the end of an incident similar to the end of a chapter in a book. To accomplish this the cameraman must slowly close the diaphragm on his lens or the shutter opening on his camera. Either will produce the same result. Some cameras have an automatic closing and opening shutter that performs its complete movement from open to shut in 10 turns (five seconds or five feet) and vice-versa. These automatics work by merely pressing a button and holding it down until the indicator shows shutter to be closed. If the button is still held down the shutter will begin to open again as the pressure must be removed as soon as indicator shows "shut" and a few more turns given to the crank handle to insure that all of the fade has been wound up into the take-up magazine.

The "fade-in" is exactly the reverse of the above. The operator starts with the shutter or diaphragm on lens closed. He gives first a few turns of crank to insure bringing fresh film stock into his camera and then gradually opens either lens diaphragm or shutter until fully open or until open to the desired point. All this time, of course, the other hand is keeping the crank going steadily and accurately two turns to the second. It will require a little practice to do these two things at the same time. For this reason an automatic shutter is very desirable as it does not take the operators mind from his turning.

Some lenses do not diaphragm completely shut. Any lens can be made to close entirely by having an optical worker fit an extra leaf in the diaphragm which has a little projection on its end. This small projection folds over the other leaves when the lens is diaphragmed down below f.64 and closes out light completely. It does not affect the working of the lens at all when it is used at various openings although it may appear to one that the projection would cast a shadow. It must be remembered, however, that every point or node of an anastigmat lens is projecting the image all over the field from every point or node on the surface of the lens. The projection on the diaphragm only cuts out a few of these rays and therefore the only effect is to make the lens work a very little slower, so little that it need not be taken into consideration. The small projection is, however, very small and only of sufficient size to cover the pin-hole opening of f.64. Do not allow an incompetent optician to fit a large clumsy projector piece to a diaphragm leaf.

Bausch & Lomb, Rochester, N. Y.; E. B. Meyerowitz, New York; C. P. Goerz, American Optical Company, New York; are some of the concerns which do this kind of work.

There is also a method of honing the blades of a diaphragm down to a razor edge so they will close completely but it is a decidedly delicate process. The worst of this is that the blades do not last long after they have been honed but soon cut themselves to pieces.

To make a fade, however, a lens does not necessarily have to close entirely. The cameraman can, the moment his diaphragm has been turned shut as low as it will go, begin to speed up on his crank and at same time place his left hand in front of the lens, being sure to keep cranking a few turns after doing this. The effect will be perfect. The same can be done in fading-in. Start with a fast crank, at same time removing hand from lens and quickly slow down to normal crank speed at same time beginning to turn the diaphragm open to the point you desire to work at.

An average fade should be about five-feet—ten turns of crank.

A fade at the end of the entire picture, (Final fade) should be about ten feet—a slow fade.

Fades of fights or exciting action should be quick—either when in or out fades. They should not cover more than three feet or six turns.

A similar result to fades is the circle-in and circle-out.

This is accomplished by a diaphragm that fits on the lens

*(Courtesy of the Christie Comedy Corporation)*

A CHRISTIE PICTURE REQUIRED A "VISION" INSERTED IN A PICTURE WITH CALIFORNIA LOCALE, SO A REPRODUCTION OF A DEVASTED STREET IN FRANCE WAS MADE.

hood of the camera—sometimes called the sun-shade. It must set at least three inches in front of the lens (2-inch lens). This diaphragm has a lever projecting to one side and while turning the crank steadily the cameraman uses his free hand to push this lever one way or other to either close or open the diaphragm leaves. This produces on the picture a circular shadow entering from the edges or corners until it completely circles the picture out. The effect is very pleasant if carefully done, but a jerky movement of the lever is worse than if the effect had not been attempted.

A circle-out should never be less than five feet in length. This means ten turns of the crank during which the diaphragm lever must be steadily pushed in its proper direction with the other hand.

The diaphragm may also be used to shade or vignette the corners of the view. The diaphragm can be used for numerous purposes. It may be used to cut out a bothersome bit of sky in one corner or to cut out an objectionable side of the set. I have used it frequently to shade out the corners of the film where a lamp was placed very close. In this manner, I obtained the strong effect from the lamp that I desired and at the same time avoided flare in the lens.

Care must be taken that the diaphragm does not slip after it is set. Some diaphragms have set screws to fasten the lever in any position.

Keyholes on the screen are produced by means of a metal mask that is fitted in front of the aperture-plate of the camera, and, of course, back of the lens. The keyhole is usually cut in thin brass by means of a very fine file and the edges then smoothed by rubbing with a very fine emory cloth followed by rouge-cloth such as jewelers use, the idea being to obtain a very smooth edge, otherwise the edge will enlarge on the screen and appear ragged. There are, in most cameras, two small springs to hold these "masks" in place when they are set in front of the aperture plate. After they are placed, focusing is done through the ground glass as heretofore. The keyhole will appear as picture and all around it will be black.

Of course, a variety of different openings can be cut in thin brass and thereby can be obtained such effects as looking through either a plain or latticed window, looking out through the entrance of a cavern, etc. In the cavern effect it is a good idea to leave the edges rather rough to give the effect of rough rocks.

To give the effect of binoculars two circles which overlap each other are cut with a drill. To obtain a smooth overlap it is necessary to first solder the thin piece of brass to a piece of heavier brass or soft iron. Then drill through the thin piece into the heavy. After the two holes are drilled heat the pieces and they will melt apart and you will have a thin piece or mask with perfectly smooth and clean-cut edges.

A telescope is done in the same manner only there is but one hole. As a matter of fact, when the eyes look through binoculars they see but one opening if the binoculars are of any account at all and properly adjusted, but popular custom has decreed that binoculars are double circles and they are invariably so represented on the screen.

Sometimes when showing binoculars the view as seen through them is out of focus at first and then comes into sharp focus as the holder of the binoculars is supposed to adjust them. This is done by first focusing the camera on the view and noting the mark at which the calibrating dial is pointed. Then deliberately throw the camera out of focus, and, while turning, bring the focusing dial back to the correct mark.

There is no end to the variety of fancy frames and masks that may be cut for the aperture of cameras. They range from plain ovals and circles, to intricate lattice-work effects and geometrical designs.

In over-sea countries the fancy masks are used a good bit more than in the United States.

### Visions on Dark Walls

We now come to the many varieties of visions that appear on walls, against doors or in dark fireplaces, etc.

The student will now have to learn to count while he is turning the crank. He must not count every turn but every other turn. If he tries to count every turn he will find that his breath will give out when he reaches about one hundred or so. He must count aloud so that the actors can hear him above the buzz of the arcs.

Suppose we have a scene that calls for an actor to cross the stage, seat himself in a chair, remove a letter from his pocket and look at it. He leans back in chair and looks at wall above fireplace, and, as he does so, there "fades-in" a picture, above the fireplace, of his brother's face.

We proceed thus: The entire scene of the actor crossing the screen and sitting down, looking up, etc., is taken first. The cameraman places his film in the camera gate after carefully focusing and observes when the two pins that pull the film down after each exposure are exactly at the bottom of their downward stroke. He then marks the two holes that these pins engage in when at the bottom of the down-stroke. This can be done either by pencil or by cutting a notch opposite the perforation we wish to mark. The system of marking depends upon the construction of the camera. On a Pathé it is difficult to mark under the gate so a scratch mark is made on the side of the camera plate which will come exactly opposite a perforation in the film when the pins are at the bottom of the stroke. The idea of this is so that the film can be rewound and set to exactly the same mark to start again. If it were to be one or two perforations out of true the picture would be out of frame when taken the second time and the vision, instead of appearing above the fireplace as we desire, would probably be up half way between the pictures which would never do.

Having assured himself that he has marked the film so that he can return it to exactly the same place, the cameraman takes three turns of his crank to make sure he has fresh stock in camera and stops with his crank handle down—straight down. He is now ready to start. It is now important that actor and cameraman start at the same moment so the cameraman starts his handle and after two revolutions says loudly, "one" after two more turns he says "two" and so on. The actor goes through the scene in this case regardless of the counting up to a certain number which has heretofore been agreed upon at which point he is supposed to be looking at the vision. We will assume that at 20 he is to see the vision of his brother. When the cameraman's count comes to twenty the actor looks up at the spot on wall where the vision is to appear as previously agreed. He looks until the cameraman comes to—we will say 30—when the actor removes his gaze.

The cameraman counts up to the end of scene or when the director says "cut" or "through." He (the cameraman) now reverses the belt on his take-up magazine so the film will wind backwards. He must be SURE TO CLOSE THE LENS, no light must reach the film on its wind back through the camera.

Having closed everything tight against light and reversed belt the cameraman begins turning his crank backwards counting at the same time until he has counted backwards as far as he had previously gone forwards. He now takes the additional three turns that he took at first and opens camera. The film should now be at the exact point at which the scene started. Now, before doing anything else he OPENS THE LENS and REVERSES BELT ON TAKE-UP AGAIN as it must be for turning forwards.

He can now remove the film from gate and focus for the vision.

This vision need not be taken at the same place at all. It is preferable to have the brother seated before a black cloth with plenty of light on his face from both sides and not much deep shadow except on the black cloth, of course.

In order that the vision will be at its proper place on the screen before leaving the set-up in which he took the film just exposed, he made a mark on the ground glass of the space occupied on the ground glass by the space over the fireplace where the vision is to appear. (If the ground glass is too smooth on the glass side to take the mark of a fountain-pen use a piece of ground celluloid instead, in this case—turning it towards the rear of the camera, but use it for getting position only as, being reversed in the camera it would not give the proper focus if used for focusing by. Focusing of the vision must be done on the regular ground glass—that is—the bringing of it into sharpness and clearness.)

The person who appears in the vision, having been placed before the black cloth and camera set so he occupies the correct position, the cameraman proceeds to mask out or cover all parts of the scene except the vision itself. This can be done by means of the outside diaphragm already explained if it is mounted on a sliding base by means of which it can be brought to any position desired in front of the lens, or it may be accomplished by means of pieces of electrician's friction tape being stuck across the front of the light-hood or sunshade of the camera. These masks or whatever is used must be about three inches in front of a 2-inch lens.

Everything but the vision being covered the film is now re-set

(*Courtesy of the Universal Film Company*)

THESE PHANTOM-LIKE FIGURES SURROUNDING THE BOY IN "THE ROAD TO DESTINY" WERE PROCURED BY A DOUBLE-EXPOSURE OF THE FILM.

in the gate so that the pins will engage the same perforations at the bottom of the stroke as heretofore explained, the camera closed and three turns of the crank taken as heretofore ending with the handle down as before. The lens diaphragm is closed and the operator holds his hand over it if it does not entirely close or else the dissolving shutter is closed. The operator now begins turning, counting as before but the LENS REMAINS CLOSED up to the number where the vision is supposed to appear. In this case the vision is to appear at 20. So at 20 the operator removes his hand from front of lens and "fades-in" for five feet counting all the while. Or if he is using an automatic shutter he presses the button at 20 and holds it to 25. He now keeps on turning, the vision being meanwhile photographed and at 30 in this case, he quickly (about three feet) fades out; the vision, of course, vanishes as he does this. The operator must continue turning with his hand over lens or shutter closed until he comes to the full count of his scene as counted the first time he ran the film through the camera. The vision and scene are now finished.

If the vision is to appear against a light object such as a white hospital wall or a book a different process must be used.

The film is set the same as heretofore, but at the point where the vision is to appear a piece of dark cardboard is slipped in front of the lens in a slot in the sun-shade or hood to a point previously determined and with a pin stuck through the card so it cannot go too far. This is prepared before the scene is taken. It is called a corner vision and the card being passed in front of the lens while count is going on and crank turning, will cause a gradual shadow to grow in one of the corners of the picture which will form a background for the vision which is taken later.

If the vision is to disappear at a certain count the card is merely drawn away from in front of lens at that number. The time occupied in placing and drawing the card should be about five seconds or five feet. After taking the full scene it is now important to take a test piece. This is taken with the black card in front exactly as it was for the vision and about three feet should be taken for the test. This is now notched—opening the camera to do so, and just above the notch written in pencil on the face of the film "Test on this end, vision."

The piece of film is now taken to the dark room in its magazine, of course, and there rewound, a piece of the end being first torn off and laid aside for the moment. After the film is rewound it is placed in magazine ready to be placed in camera and the vision part taken. Before going further the test must be developed. This can be done by the laboratory but to get it quickly I advise every cameraman to have, in his dark room a small jar of strong developing solution and a small jar of hypo fixing bath. He dips the test piece of film into this and developes it and fixes, after which it is rinsed in running water and hung up at a window to dry which it will do within an hour if weather is dry.

When ready to place the vision this test piece of film is placed in the camera the same position that the film will occupy—viz., upside down and with the emulsion towards the lens. The ground glass is slipped in back of it and the film pulled up or down until the claws or pins engage in a perforation which will bring the film into correct frame when viewed through the magnifier or focusing aperture.

The operator can now see the shadow made for the vision only in this case it will be clear film—being a negative. He can now adjust his camera so that the vision occupies this space and by means of diaphragm or black tape or cards as heretofore he can block out all the parts of the picture except this corner where the vision appears.

He should now remove the piece of test film and focus on the ground glass for sharpness. Then place the film in camera and set it to the point previously marked as heretofore and CLOSE THE LENS. He now begins the count and at the proper count fades in the vision as previously explained.

But we will assume that the vision is not to be in a corner but in the center of a white page—as a letter.

To obtain this a piece of clear glass is used with a small patch of black paper pasted in its center. This glass is moved about until its proper position is secured by means of the ground glass and then it is marked so it can be replaced in this exact position later.

The film is now placed in camera and marked so the same position can be obtained when run the second time. We will suppose that ten feet are to be run before the vision appears. The film is run up to ten counts and from ten to fifteen counts the diaphragm in the lens is slowly closed—in other words—a fade-out is made.

The belt on magazines is now reversed and WITH LENS STILL CLOSED the film is wound back five feet (not the whole way this time). The belt is now changed back again and the piece of glass with spot in center is adjusted. The lens is still closed. The operator now begins turning again and counting from the point he turned back to, ten in this case, and at same time performing a fade-in. This will cause the dark spot to gradually appear on the letter although the letter or page does not change at all. A test is made at the end of the scene as heretofore to enable the cameraman to place the vision at the correct point and to assist him in blocking out all other objects.

The vision is then photographed as heretofore fading in at the same count at which the black spot was faded in. The black spot must be of sufficient size to accommodate the vision.

All numbers and counts etc., should be marked down in the cameraman's note-book immediately and not left to memory. It is easy to forget or become confused about numbers.

One of the best methods for keeping memoranda of numbers is to mark them, with lead-pencil on the film itself—that is—on the loop that is exposed when camera is opened for focusing and just before the scene that they refer to. For instance:

Mark on film something like this:

Vision—May asleep in chair sees face of mother
Face fades in 30 to 35
Face fades out 60 to 65
Scene runs to 85
5 ft. test on end.

It is sometimes not convenient to finish the making of the vision the same day the first part is taken. If some time will elapse between the first and second takes the film may be removed from the magazine, rewound and canned. This can must be carefully labeled and set aside where it will not be sent to the laboratory by mistake.

Cans should be labelled somewhat like this:

Vision No. 67 (or whatever number scene is).
May asleep in chair sees face of mother.
Counts in notebook (or on film end).
Rewound (or not rewound yet).

If a test has been made and developed it should be taped on top of the can so one can see at a glance what the can contains. 200-foot cans are good for this purpose as they take up less room than the larger 400-foot ones.

A *dissolve* is one scene diffused into another. It is accomplished by merely making a fade-out and a fade-in overlapping.

For instance, if the first scene fades out at 20 to 25—the cameraman merely winds back the film five feet (with the lens closed) and then fades-in for five feet while turning forward again on the other scene.

It will be found that dissolves are more perfect if they overlap more than normal. That is to say if a fade-out is made from 20 to 25 it is a good idea to turn back to 19 (instead of 20) and to begin the fade-in from there to 24 (instead of 25). This will prevent any tendency of the film growing dark where one view fades into the other.

As with visions a memo should be made of numbers at which dissolves occur, and, if the second scene is not made the same day the film may be canned and set aside.

Enough blank film must, of course, be reserved so that the second scene may be dissolved onto the first and an ample amount left for the succeeding scene. For this reason the director should tell the cameraman about how long he expects his second part of the dissolve to run, or, in case the second part is taken first, as is often the case, how much blank film shall be left in first part of roll to accommodate the first scene.

Sometimes as many as five or six scenes are dissolved—one into another, in which case the cameraman must calculate what the total footage of all the scenes will be and allow enough film on the roll.

In making a number of dissolves—one into another—the cameraman must be very careful not to get his numbers mixed. It is well to take all dissolves twice, so as to have a second take in case of a mistake at the time the first is taken. These should be marked first and second take on the film before the camera is closed.

One cameraman had ten dissolves to make—one into the next. He went along and had nine all right but became confused on the tenth and, of course, the lot were spoiled. This work took almost a week to do and probably cost the studio $500 or more.

*(Courtesy of the Universal Film Company)*

THE ONLY ACTORS WHO NEVER DISPLAY TEMPERMENT INTRODUCED BY JAMES S. HORNE, JIM CORBETT'S DIRECTOR.

Often the director will call for a dissolve into a close-up. To do this quickly—first focus the long shot and note the mark on focusing dial at which needle points. Now move the camera up to the point from which you wish to take the close-up and make a mark with chalk where tripod legs meet the floor. Set focus and note the indicator dial. Now move back to long-shot position which may also be marked in chalk, set focus dial back to long-shot mark and go ahead. When director calls "dissolve" fade-out for five feet, rewind with the lens closed, move up to marks previously made, reverse belt, set focus to the close-up point previously determined and point camera correctly by means of the finder on side. When ready say so to director and when he says "go" begin turning and at same time fade-in for five feet (ten turns).

If now the director wishes to dissolve back to the long-shot and says "dissolve" repeat the above except in this case set the focusing dial back to the long-shot position and move camera back to original position, adjusting the camera correctly by means of the finder.

Miraculous appearing scenes where the costumes or surroundings change before the eyes, are often required. For example: suppose the actor's ordinary costume must change to the uniform of a soldier. To do this, run to a pre-determined number, say 20—and then fade-out. The actor has been previously instructed that at 20 he is to hold absolutely still until told he may move. After having faded out from 20 to 25 stop the camera and carefully mark the actor's general position. The position of his feet is marked with chalk and the position of his hands on table is marked likewise. The place his head occupies is marked with pencil on the ground glass of the finder and care is taken that no one moves the camera in the slightest degree. The actor is now told to go to his dressing room and put on his uniform which must be all ready for him before the scene is started. While he is doing this the cameraman reverses the belt, winds back five feet with the lens closed and awaits the return of the actor. When actor has made his change he is placed in exactly the same position as he previously was, his head at same place on ground glass, his hands on the chalk marks which are now carefully erased and his feet exactly as they were. It is never possible to get identically the same pose, but the blur caused by the dissolve with its confusion to the eye will cover any small changes.

When actor is placed he is instructed to hold perfectly still until you count five. After this he may do whatever the director wishes. Turn forward and at same time fade-in for five feet and continue turning until scene is ended.

Miniatures are frequently used to simulate wrecks of trains, boats, etc. The success of these tricks depends a great deal upon the skill with which the miniature-man builds his toys. Some makers of these diminutive models are very skillful and can construct a war-ship, castle, bridge, or whatever is required, correct in every detail. In using miniatures on water in a studio tank, take care that no bubbles form as they would appear very large—about the size of hogsheads compared to the model-ship—and give the trick away.

A great deal depends upon the lighting used on models. It should not be too harsh as that tends to throw details into strong relief and the possible crudeness of the object is exaggerated.

Burning trestles are usually soft wood saturated with turpentine which produces a black smoke that photographs well.

Explosions are usually produced in miniature with the use of slow burning flash-powder.

Wind comes from a nearbye electric fan, and rain from an overhead tank in which a number of small holes have been punched or from a hose with a spray nozzle.

Toys and dolls may be brought to life and chairs, tools, etc., caused to perform any actions the operator may desire by means of the stop-motion crank which has been explained. When taking a stop-motion of a doll walking, the cameraman turns one revolution thereby producing one picture—he then advances one of the doll's feet a very little and takes another turn on his camera. He then gives the doll's foot another move forwards and another turn of crank and so on—endeavoring to produce lifelike motions. It must be remembered that in stop-motion work the light must either be much weaker or else the shutter or diaphragm be closed down enough to make allowance for the comparatively slow speed at which the pictures are taken.

An illusion that is easily explained is that of a man climbing up the side of a building. He lifts himself up past windows and balconies until he reaches the roof. In this case, the house's side is built on the studio floor—flat against the floor and not upright. The camera is taken up into the girders at the top of the studio and pointed straight down. The man who does the climbing does not really climb but merely drags himself over the floor which, in this case, is made to resemble the side of the house. When viewed on the screen the house, is of course, verticle. The illusion is complete.

This same method is used with many different backgrounds painted to resemble the bed of the ocean or the moss and ferns at the bottom of the sea in perspective. One of these is laid on the studio floor and a woman attired as a mermaid drags herself around with the motion of swimming or is swung on a thin wire a few feet above the floor. To finish this illusion the same piece of film should be again run through the camera. The second time the film is run through the camera, the latter is focused upon a small flat aquarium in which fish are swimming. This aquarium should have a flat glass side and be backed up with a black cloth on the side furthest from the camera. The camera itself must be covered with black cloth leaving only the lens exposed through a hole cut in it. This black cloth should cover the cameraman as well otherwise the glass of the aquarium will reflect everything in front of it and the camera and anyone near it will appear in the finished film. After the second exposure, the film is developed and the effect will be that of a woman swimming among fishes at the bottom of the sea.

The warning about reflections in the lens that are given above also holds in photographing a close-up of the human eye. In doing this, a cameraman must be very careful how he places the lights or he will have a reflection of every light in the studio in the curved lens of the eye and, when this is enlarged to fill the screen, the reflections will be plainly visible. Again, in this case, the camera and operator must be in black or covered (except the lens and the operator's eyes), with black cloth.

Actors often have to play dual rôles—that is, play two characters in the same scene. To make one actor talk to another figure—the latter being himself—an instrument is used to split the stage or frame in two sections. This is an opening in the sun shade—about four inches in front of the lens in which two black cards slide so that each card can be moved across until one-half of the ground glass is black or shaded. The action is first carefully rehearsed so that the actors know exactly what to do at certain counts. After one side is taken the film is rewound with the lens closed and the other card moved across until it just touches the first one and the first one is then removed. This shades the side of the film just taken and exposes the other side. The lens is now opened and the other side taken. If the cards are manipulated carefully and the actors are careful not to cross the line or the blend of the two sides the illusion will be perfect and no division of the stage will be seen.

The action, in this case, must be carefully timed so that the two figures will speak and answer at the proper instant.

There will be, of course, a space in the center of the picture beyond which neither person may venture or they will simply vanish. If, even, a hand is passed across this forbidden space it will disappear. There are, however, methods of crossing this dividing line and having one of the figures follow the other off the stage. The action goes up to a certain point and one figure leaves the stage. We will say it is the figure on the right. Left now holds his position for a few moments and follows off.

This is accomplished by having a certain count agreed upon at which right leaves and is OFF stage. At exactly this point the camera is stopped. We will say it is count 40. The film is now reversed and run back to start and the left side taken. At count of 40 the actor known as "left" must remain perfectly still. That is hold. The camera is stopped and the mask covering half of the lens is removed. The camera is now started and the actor "left" has the whole stage to act in if he desires. When the film is developed there will be a fogged place or possibly a few inches of black film where the stop was made, but this is cut out and the ends of the film carefully joined together with cement. If this is done skilfully no jump will appear on the screen where the mask was removed.

Triples or three persons on the screen at the same time, the three persons being one and the same individual are made by using three masks, one in the center and one on each side.

An example of this is a scene showing a man at telephone on one side of the screen, a girl at 'phone at the other, and between the two, a panel of a city with telephone wires.

The two sides are usually taken first and then the mask set and the outside view taken. This means that the film must go through the camera three times or that the two outer scenes may have been taken at the same time by placing the two sets close together the centre exposure masking the junction of the two sets.

A vision in a mirror is done by means of a piece of black velvet fastened to heavy cardboard which is made to exactly fill the frame of the mirror. The lady seated in front of mirror sees her own reflection up to a certain point when suddenly her reflection changes to a vision of her enemy—a fierce looking man. We turn the camera up to the point where the vision is to appear. In this case let us say 20 to 25. Fade-out from 20 to 25 having actress hold her position during fade—and not move afterwards. Quickly wind back five feet of film as heretofore and at same time have stage-hands fit the black velvet into the mirror frame. When this is done fade-in and actress can now move again and register horror at what she sees in the glass. After scene is ended be sure to take a test to show exact location of the mirror—otherwise you may have great difficulty in placing the vision squarely in the centre of it.

When making the vision fade-in on the film from 20 to 25 and be sure to have plenty of black cloth back of the man posing for the vision and to block out that part of his figure which comes below the line of the mirror frame else the vision will spread all over the dressing table or whatever the piece of furniture containing the mirror may be.

A good method of masking out mirrors is to take a piece of the test and cut out the mirror opening carefully and then opaque the piece of film with indian-red water color. Place this piece of film as a mask in the aperture back of the lens and in front of the film and the only part of the film you will expose will be the mirror. The mask must be carefully placed by means of a piece of the same test. For this reason make plenty of test of a mirror scene.

Ghost or spirit figures are often required. First take the regular scene and then rewind to the beginning. Now have all objects in the set covered with black cloth. Velvet is best. See that camera is not disturbed in the slightest or moved even the slightest particle. A black drop is used to hide the background. In other words everything is black. The actor portraying the ghost now enters the scene and the film is run through again. This actor should not be dressed in black or he will not show. Ghosts are always to wear something light otherwise only their faces would be visible against the black ground.

The above effect will produce a visionary figure—one that can be seen through or is partly transparent.

To cause the illusion of a soul arising from the body and floating away, the figure is first photographed to end of scene and the film re-wound. We will assume that the figure from which the soul emanates is to be seated in a large arm-chair. At a certain count (say 30) the actor must be in this chair and remain seated there until the end of scene.

After rewinding the film to the start cover everything in the set with black velvet and have the actor sit in the chair again. Now close lens and turn to 30. At the count of 30, fade-in while simultaneously the actor slowly rises from the chair and with a gliding motion crosses the stage and exits.

The effect will be of the man remaining seated in his chair all through the scene while the spirit-like figure of him will rise from his body and move slowly away from the living being and out of the picture.

An illustration or picture in a book may be required to come to life and move. In this case a girl reads a paper showing an illustration of the "toughest tenement in New York" she is shown reading and the scene jumps to a close-up of what she sees in the paper. Show section of page with view of front of building—people passing and children playing in street. This is a still picture. Suddenly the people begin to move and the children to run about. This is accomplished by taking a motion camera and a still-camera to the same location and setting them to focus on the same scene.

About twenty feet are run in the camera with lens closed and at the count of 20 the cameraman starts to fade-in and at same time his assistant snaps the still-camera. The scene is now run to end. After returning to the studio the still picture is developed and a print made of it. This print is now fastened up on wall and the motion-camera focused carefully on it. The film has been rewound to start and the cameraman now photographs the still up to count of 20 when he fades-out. If he does this at the correct count the still picture will merge into the moving one and the figures will appear to come to life.

Some very astounding illusions can be performed by double printing.

We wish to show an airship sailing up Fifth Avenue, New York, only a few feet above the heads of the people:

First, a good view of Fifth Avenue is taken, looking straight or nearly straight along the street. This is developed but not printed. The negative is laid aside for the time being.

A miniature airship is now built and suspended by two WHITE threads so that it can be pulled towards the camera along an overhead wire for quite a distance—in this case about 15 feet. Back of the airship and covering the entire field of the lens is stretched a white sheet or background which must be well lighted so that it will photograph brilliantly white. The camera is now set so that the airship will, when drawn along the wire grow larger and finally pass out of the top of the frame when it is quite close to the camera. The focus will be set about midway of the airship's travel and may either be changed as the airship approaches or left stationary. There is little advantage in this case in changing focus. The airship itself must be painted gray or drab so that it is visible against the pure-white backing.

After this piece of film has been taken it is developed and the result should show the airship approaching against a jet black ground (this being a negative).

A print is now made from this negative on positive stock which must be printed so deep that the airship, instead of being gray or drab as in the original, appears black or nearly black. In other words a very dark print is made. This should show a black or nearly black airship approaching against a pure-white or clear film background.

We are now ready to superimpose the airship against the background of Fifth Avenue. The piece of negative of the street is placed in the printing machine and against its face is placed the piece of print of the airship with the clear film background. A mark is made on the perforation of each where the start is made and then a piece of unexposed positive stock is placed in the machine, its beginning marked and all three are run through the machine together. If this strip of film were now developed it would show a picture of Fifth Avenue with a white airship coming up its length but we don't wish this to be the case. Therefore, we take the piece of negative of the airship with jet-black background and match it up with the print of same so that the beginning can be made to correspond with the beginning of the print and place it in the printing machine together with the piece of undeveloped positive stock which we have just printed. These two pieces are now run through the machine and the film is then developed as regular positive stock.

The result will be a perfect illusion. Every detail of the ship will show clearly and there will be no visionary effect since the print of the airship was run through the printing machine with the negative of Fifth Avenue and this served as a mask and left a clear space which the final negative of the airship followed identically. Every rope and spar will automatically find its proper place on the masked film and imprint itself there.

To insure that the airship travels in the center of the street or where desired a piece of the negative of Fifth Avenue first taken, can be placed in the ground glass aperture when focusing on the miniature airship and the camera so arranged that it will be the right size and travel on the wire in the proper direction.

This trick need not be confined to miniatures. By building an airship large enough to accommodate living persons and having the ship so arranged that clear sky is back of it to serve for the white background, people can be seen moving about on the deck of the ship as it sails up the street.

The student will, by using his imagination, think of a variety of original ideas that can be carried out by this method.

For instance—A man leaps from one building to another while far below him can be seen the street and its traffic. The view of the tops of the two buildings is first taken and the street showing below. The jump itself is performed from one white covered box to another in the studio against white backing and if the leap is to be exaggerated the actor is merely swung on a steel wire painted white. The position of the two white boxes is arranged by placing a piece of the negative of the roofs in the camera and arranging the boxes to fit the exact position of the edges of the roof.

Also a man can be shown running along a street at the rate of a hundred miles an hour by this means:

A view of the street is first taken from an automobile traveling along. This should be taken side view to the street and the camera turned slowly so that the streets will apparently fly past very quickly. This negative is later used with one taken in the studio showing the actor running on a tread-mill painted white and against a white backing as heretofore. Any number of apparently impossible effects can be otained by this method. There

(*Selznick-Photo*)

A MADE-TO-ORDER STORM

is no end to the variety of effects such companies as Keystone, Sennett and others obtain by its use.

Scenes showing lightning striking people or buildings are often needed. An actor comes to the door of a house during a storm, he is immediately struck in the chest by a bolt from the heavens.

This is done by counts. The perforation is marked so film can be reset in camera to start. At count of (say 30) the actor is to receive his supposed stroke. So he must be at the door by about 28 and just as the cameraman shouts 30 the actor must recoil as if struck and fall. The film is then run to end of scene.

A test is now carefully made—the actor returning to as near the position he occupied when struck as possible. It is well to take the above scene several times as much depends upon whether the actor returns to his exact position for the test.

The film is now re-wound and the test developed.

This test will be placed in camera back of ground glass later to find the correct place for the bolt of lightning to strike.

You will now need an induction coil, such as is used for X-ray work, capable of throwing a six-inch spark. This can be rented from the Marconi Wireless Telegraph Co. or obtained from some X-ray operative or electrical store.

It is set up and covered by a black velvet cloth so that only the two balls between which the spark jumps are exposed to view and these are painted black with non-lustre varnish.

The camera is now adjusted so that one of the balls is placed against the actor's breast on the test—as seen in camera, and the other one is against a post in the sky from which the bolt comes. The switch on the electrical machine is then closed and the effect of the jumping spark is noted on the ground glass and test. If it looks natural and effective the bolt is ready to photograph. It is advisable to throw the spark itself a little out of focus as this will give a sort of halo to the bolt and make it look more hot and natural.

Everything being ready the film is placed in the camera and set to its proper mark and the lens opened. The cameraman starts turning, counting at same time. As everything is draped in black he is getting no picture. There must be very little light in the room however. At the exact count of 30 the assistant presses the switch or key for just one instant and the cameraman then continues to the end of his scene and the bolt has been photographed.

This should be developed before the other takes are finished to see if everything has gone right. It is quite a tricky piece of business.

When making scenes on board ship or in a ship's interior set the effect required is that of a ship rocking at sea. Place the camera, sideways on the tripod-tilt. While turning the crank have your assistant also turn the tilting handle several turns one way and then reverse the motion. This must be done steadily and not too fast, never jerkily.

Camp-fire effects at night are obtained by several methods. The most effective I ever obtained was by digging a hole in the ground about two feet deep and setting an arc light in this, with the wire leading away from the trench covered by a layer of ground. The arc was turned so that its rays were thrown upward into the faces of the men grouped around the spot. In front of this trench, that is, on the side towards the camera, were placed a few logs of wood and some leaves saturated with kerosene. The background consisted of an old tree trunk standing in the studio yard where this scene was taken.

The camera was focused on a flash-lamp bulb held by my assistant directly over the spot where the fire was later ignited. I also measured the distance with tape and checked up on the calibrated camera scale. When all was ready the logs were lighted, the current switched on in the arc and the men gathered around the fire. I had the diaphragm of my lens wide open—f.3.5 and shutter at normal. I turned a little slowly—about 4/5 normal speed. The positive film was tinted red and was all that could be desired.

Another method, where electricity cannot be obtained, is to sink several slow burning magnesium torches in the hole in the ground. These are made by Newman of New York and are quite expensive so that, wherever possible, electric arcs should be used. Also, the flares only burn about two minutes and emit volumes of smoke which often entirely hide everything from the lens.

Smoke-pots are a sulphurous combination of powders that can be purchased at any theatrical supply house and are used to "fake" fires in daytime. Several smoke-pots lighted behind windows will produce volumes of thick, yellow smoke that will roll through the window giving the effect of a hot fire within. They are harmless inasmuch as they never produce any real amount of heat nor can they explode. The smoke they pour forth quickly disappears. It is, however, very non-actinic and photographs effectively. It is also used by "miniature" workers in miniature volcanoes. When these effects are tinted red they are most convincing.

## Chapter XVIII

# COMPOSITION BY J. C. WARBURG

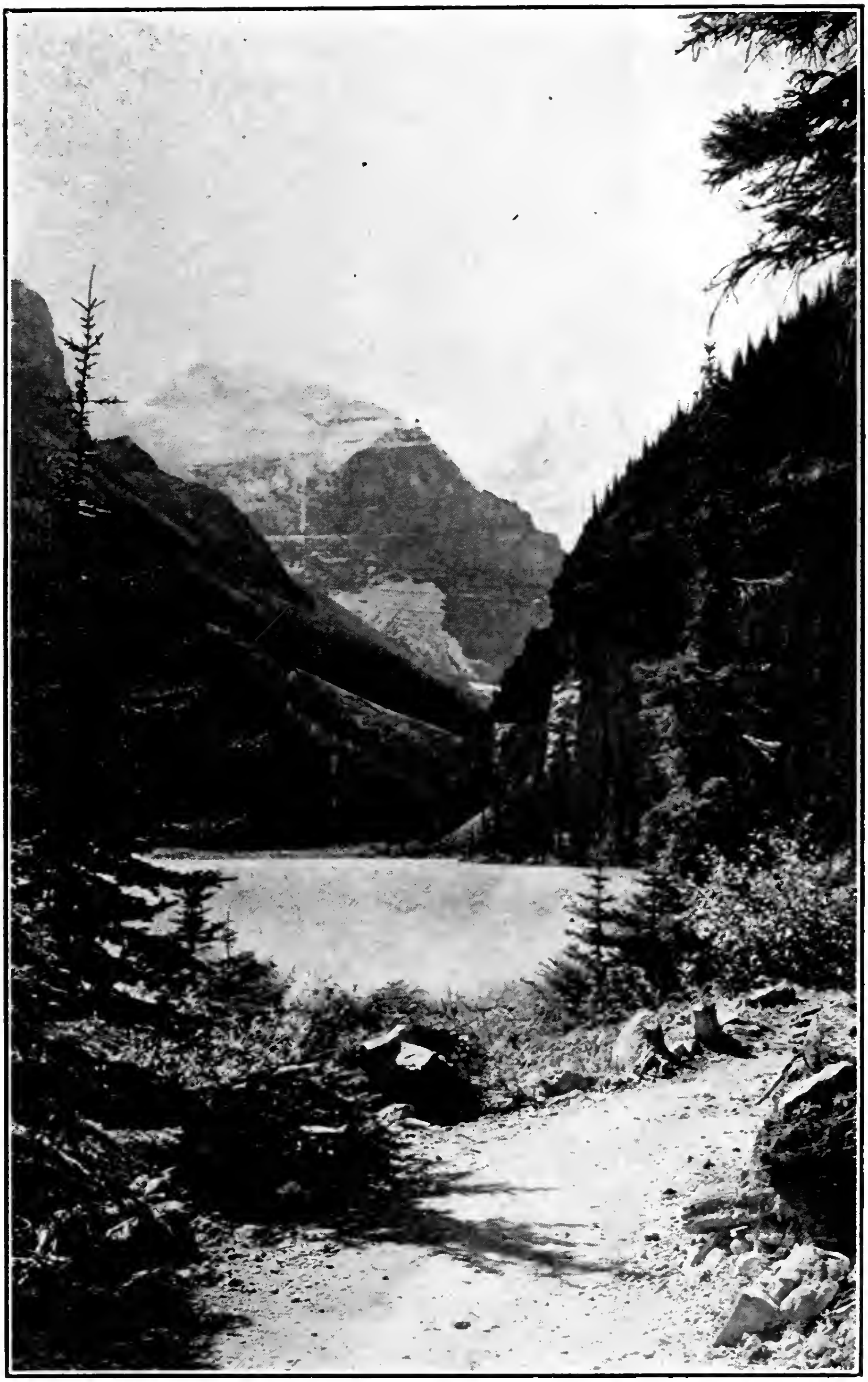
UNDOUBTEDLY the most important phase in the production of a picture is the choice of subject, and in no case, paradoxical as it may seem, is this so important as in pictures which, to the "man in the street," have no subject.

The fact that a particular view or landscape is pleasing to the eye is not necessarily a reason for its being pleasing in a picture, for there is an essential difference. Nature is an unlimited, unbounded reality, possessing color, relief, solidity, distance, atmosphere, and other attributes, which can only be represented, not reproduced, in a work of art. While nature is an entity, art is an illusion, a symbol, based upon and recalling nature, but appealing to us in a different way. Though lovers of art are also lovers of nature, they do not enjoy a visit to a picture gallery in the same way that they enjoy a walk in the country. A picture, however real in its illusion, can represent only a small portion of nature—a small slice of it.

Here we have the first reason why a pleasing landscape will not necessarily give a pleasing photograph. The photograph has an outside boundary, a hard edge, where it is cut out of nature. The eye cannot wander beyond this edge and find fresh beauties as it can in nature. We are brought at once to the formal limits of our subject.

If the eye strives to go beyond the limits of a picture, the result will be restlessness and want of completeness. The objects at the margins must not be so attractive as to lead the eye out of the picture. They should not suggest the violent exclusion or excision of parts of nature. To give instances, great circumspection is necessary in introducing overhanging branches of trees not themselves included in the picture, or of showing a tree without giving an indication of the ground from which it grows; do not infer that such objects are never allowable. Each case must be considered on its own merits.

A picture has a two-fold aim. It aims not only to represent nature, but also to be a decorative design. The lines and masses



THE LINES AND MASSES OF A PICTURE MUST HAVE BALANCE IN ORDER TO PLEASE THE EYE.

of the picture must have a certain balance or rhythm in order to please—hence the importance of "composition."

The photographer, unlike the painter who can shift objects and place them where he likes on the canvas must find his design in nature. He has to move his camera right or left, backwards or forwards, up or down, until his focusing screen includes a pleasing design.

The problem is to fit the picture into the space satisfactorily. The picture must not look as if it were cramped and forced into constraining limits. It is also necessary that all parts of the picture help the general effect and belong to it. Extraneous objects, confliction of lines, division of interest, all detract from the force of the picture.

The general design should be simple. It should resolve itself on analysis into a few simple forms, or groups of forms, rather than into a heterogeneous mixture of light and dark patches and bewildering lines.

If we examine one of those pictures which attract us in a picture gallery, interesting us even before we have made out their subject, we shall find generally that it is built on well-marked but simple lines, with well massed light and shade.

The fact that the groundwork is simple has little or nothing to do with the details. These may be few or elaborate, yet the general effect of the picture, considered as a design or decorative piece remains much the same.

The subject of the picture is its most important and conspicuous part. It is generally placed toward the middle of the composition with the subsidiary objects leading to or balancing it. Unless one portion of the picture is more interesting than the rest, there is danger of the eye being attracted first to one side and then to the other. This may lead to a restless or monotonous effect. By having a principal object, supported by less important elements the interest is concentrated. Such a principal object need not be very large, nor is it necessarily immediately recognizable as the artistic motive of the picture. It may be merely a splash of sunlight on a white house, or a branch against a white cloud. In many pictures, depending for their attraction more on the mood and expression of the whole than on the actual subjects treated—on tone more than on design—it is often difficult, if not impossible, to pick out one portion of the picture as undoubtedly the principal object. Generally, however, such a centre of interest is discoverable.

Many authors have sought to determine mathematically the best position for such principal object and their results may be useful as suggestions rather than as rules. It has been stated, for instance, that if a picture be divided into three, or into five, equal parts in both directions, the points of intersection of the dividing lines will be the strongest positions for the principal, and secondary objects. This is rarely the case, however, and it would be correct to say that such objects are rarely quite central or quite evenly balanced.

If the most important parts of the picture are placed toward the centre, it may be asked what should be placed in the margins. Generally speaking, the base of the picture should form a sort of threshold to the picture, a piece of ground or herbage, upon which in fancy we may step, the more nearly to examine the picture proper. Sometimes it is a road or path leading into the picture, sometimes the lower leaves of a plant which rise upwards, something soft and harmonious rather than detailed and emphatic.

There is a story of a French painter, who painted a picture with a wonderful foreground. He showed it to a friend, who was so full of admiration for the foreground that he could hardly look at other parts of the picture. Seeing this, the painter seized a brush and painted out most of the details, reducing the foreground to its simplest expression, in order that it might form but one item in a harmonious whole, instead of overweighing other parts of the picture and detracting from the effect.

Foregrounds, then should be unobtrusive. They should not contain great contrasts or be too sharply detailed.

Nevertheless, a note of contrast, such as a strongly lighted rock or tree-trunk on one side or other of the immediate foreground, may often be of value in throwing back objects behind it.

The foreground should not form an isolated, uninteresting patch—it should lead into and blend with the picture. Sometimes we see a more or less rectangular space of foreground, almost detached from the rest of the picture, a space which could be trimmed off without making much difference. Nearly always such disconnected islands in any part of a picture detract from the unity of the composition.

What has been said of the base applies in less degree to the top and sides. One side generally contains some important foreground object placed a short distance from the edge.

Although few photographs contain "lines" such as those in pencil drawing, yet Line is a most important matter in every branch of picture-making. If we examine a good collection of etchings, we shall notice what an immense power line possesses. The etcher has neither the color of the painter, nor, to any great extent, the gradation of the photographer. He is largely dependent on line, and uses its power to the utmost.

The photographer often overlooks the importance of line. Line in a photograph is not necessarily an actual line, such as a wall or paling, the base of a building or a path. More often it is the edge of something, a ridge of hills against the sky, or a dark bank of trees against the lighter distance. Often it is discontinuous: a row of posts or trees, a flock of sheep going down a road. Whatever it represents, and however it occurs, a fairly well-marked line insensibly draws the eye along it.

If the line is a softly undulating one the eye follows it easily, and without effort, and the result is pleasant and soothing. If, on the contrary, it is broken and jagged, the eye has more trouble in following it, and the resulting impression is one of stress or movement.

We all know the peaceful calm of a quiet sunset over the sea, the straight horizon and the parallel banks of cloud above it, or the restfulness of softly undulating downs, with, perhaps, the gently curling smoke of a farmhouse in the foreground. Compare these with the wildness of a billowy sea and storm-torn clouds, or the jagged outline of a granite crag, or the gnarled and twisted trunks of windswept trees. The mental effect is entirely different: Gentle lines, especially where they are nearly horizontal, are connected in our minds with peace; jagged and broken lines with unrest.

It may be objected that the photographer cannot alter the lines of a landscape. Nature has formed them for him to take or leave. If that is so, he can, at any rate, exercise his power of selection by taking a picture only where the lines are suitable, and refraining from exposing when they are not. But that is hardly the case. Nature provides the lines, the photographer can vary them, if not to an unlimited extent, at any rate to such an extent that out of the same subject he can often make many dissimilar pictures.

Let us take as example the case of a well-marked path leading past a tree, with the distance beyond. The photographer erects his camera in the middle of the path pointing at the tree; result, the tree in the middle of the picture, the path widening out towards the bottom of the picture. By turning the camera on its tripod the tree and lines are brought more towards right or left, but their shape is unchanged. Move the whole camera a yard to one side, however, and a marked change occurs. The path now starts from the corner, and curves towards the middle. Move the camera another yard in the same direction and the path will now enter from the side of picture, curving past the tree.

The horizon line is a line of great importance. Its position in the picture has a great influence on composition. All level or horizontal lines which recede from the eye terminate ultimately in the horizon, or would do so, if produced sufficiently far.

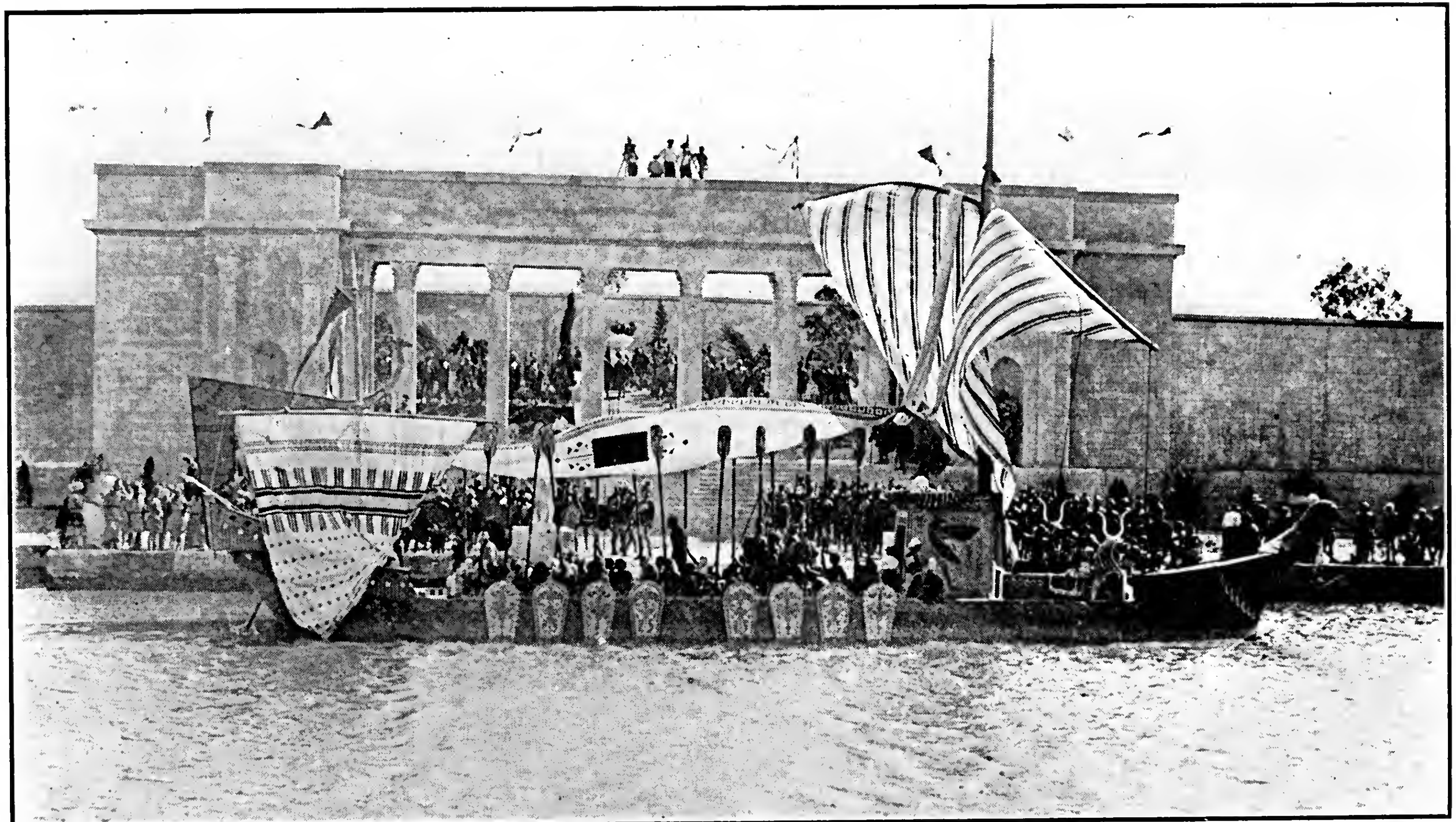
The horizon is on the level of the eye or, in the case of a photograph, of the lens. In order to obtain a true perspective of a picture the eye must be on a level with its horizon. If the picture be above or below the eye, the camera must be tilted forward or backward, in order that the line of sight from the eye falls normally (i.e., at right angles) on the horizon of the picture.

Horizontal lines above the horizon line, therefore, slope down towards it, while those below slope up. The line of a wall of, say, 4½ feet high may, therefore, be made to slope upwards or downwards on the ground glass, according as we place our camera at a height of 5½ or 3½ feet respectively.

With regard to the position of the horizon in the picture, the division of the picture into three or five comes into play here. The horizon line seldom looks well in the middle of the picture, for it then bisects the picture, making it too symmetrical and geometrical in arrangement. A much more usual position is a third or two-fifths from the bottom. In most old pictures and in pictures in which the sky forms a prominent feature, the horizon will be in that neighborhood.

The influence of Japanese art, with its strong decorative character, or the desire for change from an arrangement which had become almost conventional, has led to the frequent use of a

SLOPING LINES WELL BALANCED.



(*Courtesy of the Fox Film Corporation*)

A PICTURE WITH MANY DETAILS YET PLEASING TO THE EYE—NOTE THE CAMERAMEN ON TOP OF THE BUILDING.

high horizon, about one-third or two-fifths from the top of the picture. A high horizon gives greater scope for decorative lines in the foreground.

The photographer raises the horizon on his film by tilting the camera.

If most of the lines in a picture slope in the same direction the effect is uneasy. There is a feeling that the whole picture is sliding downward. To obviate this it is necessary that the sloping lines be balanced by opposing lines sloping in the other direction, or that some strong object be included to stop the lines sliding out of the picture. Although the lines are not actually sliding, the beholder imagines they are. Just as we stop an object from sliding by placing a heavy mass in front of it, so we can neutralize the the effect of sliding in the picture.

On the slope of a hill or watershed where most of the lines tend to slope in one direction, it may not be possible to find contrary lines of hills, but a foreground rock or clump of bushes, or a house or tree in the mid-distance, may often be secured in the field of view. Failing these, or in addition to them, cloud forms may be secured, which will give the necessary balance of line.

For another reason unbalanced sloping lines are undesirable. They lead the eye out of the picture. When balancing lines are introduced, on the other hand, the eye is led toward the middle of the picture where the lines join or cross. The tendency is for the eye to follow converging or disappearing lines toward their converging end, rather than to follow their radiations toward the edges of the picture.

Design is not only a matter of line, but also of mass. As we may have an unbalanced effect if all the lines slope the same way, so also we may get an unbalanced effect if all the larger and heavier masses are on one side of the print. Here, again, the mental effect is comparable to the actual effect of mass or weight. A "heavy" shadow appears to drag down one side of the picture, just as a heavy weight would drag down one side of a pair of scales. The blacker the mass, the heavier its effect—a property of which we may make use in order to balance a large mass of low tone on one side of the picture by a smaller mass of still deeper shadow on the other.

Large masses not too much chequered and contrasted by light and shade give dignity and breadth. White and black are uncommon in nature, and should be discreetly used. The highest light in a film, even if it is not absolutely clear celluloid, will tell better if it forms but the climax of a modulated mass of light tone (especially if contrasted by a strong dark in its neighborhood) than if it is a flat tone of unmodulated white.

Mass, and light and shade, are almost synonyms in monochrome. Therefore the lighting of the subject, the time of the day, the weather, and especially the presence or absence of sunlight, have an overwhelming effect on the arrangement of mass.

A hill against the sky with the light behind it forms a dark mass, while the same hill in a misty atmosphere and lighted from the front may merge into the general tone of the sky. We lose not only the heavy effect of the mass, but also the strong line of its edge. The lighting, then, is worthy of intense consideration.

The lights and shadows in pictures are generally found more or less massed together than chequered over the surface—the darker tones, for instance, at the bottom and one side, and the lighter tones at the other side and top.

Where a strong dark juts out against a high light, or vice versa, we obtain a contrast which is certain to attract the eye. Such a point generally forms the central point of the composition. It must, therefore, be well placed.

The most stable and solid effect is obtained by having large masses, more especially dark ones, at the base of the picture, support smaller or lighter masses above; on the principle of the pyramid.

Too even a distribution of light and shade is apt to be monotonous, and inimical to concentration of expression. For this reason, a landscape lighted from the front is generally less suitable for pictorial representation, than if lighted from the side. Similarly, evening light, with its long shadows, has a breadth which we may seek in vain at noontide.

A sky with brightly lighted cumulus clouds interspersed on the dark blue ether—such a sky we get when a storm passes off—is likely to give a much more interesting lighting to the landscape, than either a cloudless blue sky, or the dull grey of a dreary day.

Most potent of all in its effect on light and shade, is the presence of the sun.

Do not draw the inference that all pictures are best taken by evening sunlight or after a storm. The characteristics of such lighting are merely given. These matters have to be considered, but they should be subsidiary to the carrying out of one's artistic intentions. Nature has many moods, and they are all worth portraying artistically.

To take an instance where some breadth must be sacrificed for natural effect, the chequered sunlight of the leafy wood would lose its gaiety and vivacity if the sunlight appeared in large patches instead of small ones. One should endeavor merely to choose a view-point, in which these small, overlapping images of the sun on the ground are more or less grouped into masses of light. Also, one should avoid their being scattered too evenly over the whole picture, and try to arrange (by including a bit of sunless foreground, for instance) that the sunny bit forms the center of attraction of the picture.

The proportion of light to dark in a picture is a matter of individual preference and of the effect desired. Rembrandt in his work generally used much shadow, thereby enhancing the brilliancy of the lights by contrast. The French Impressionists, on the other hand, keep the whole picture light, thereby obtaining a general luminous effect. If a picture contains light and dark in equal proportions, the result is likely to be rather tame, in comparison with one in which either light or dark tones preponderate.

As in musical nomenclature, these differences are often spoken of as differences of key. Likewise, the tones of a picture, ranging from black as the deepest tone to white as the highest, are comparable to the tones in music. The whole range of tones is called the scale of tones, or scale of gradation. If the picture includes all the tones from black to white we speak of a complete, full, or extended scale.

From the photographic point of view, a full scale of gradation depends on an exposure sufficient to give the shadow detail (the low tones, without over-exposing the lights (the high tones), coupled with a developement which gives sufficient contrast to enable both black and white to be obtained in the particular printing process employed.

It may be as well to note at this point that while line is almost entirely a question of view-point, having little to do with lighting, and being almost independent of exposure, mass is a question not only of view-point, but of lighting. Tone, though depending on selection for its material, requires approximate exposure and development for its successful registration.

Photographic composition is, therefore, of a threefold or fourfold nature.

To return to our musical analogies: A picture containing many deep tones is said to be in a low key, one containing a majority of light ones in a high key.

Where there are a few gradations (or modulations, to use the musical analogy) between light and dark, the range of gradation is said to be abrupt.

The scale of gradation in nature between a light in sunlight and a dark object in shadow is many times greater than the range obtainable between black and white in a print. So great, indeed, is the illuminating power of sunlight, that a piece of black velvet in the sun may reflect more light—that is, appear lighter—than a piece of white paper or other light object in the shade.

This being the case, it is obviously impossible to copy nature's scale, except where only a very limited range of light and shade is included in the picture. The best we can obtain is a compromise, which will give us the illusion of nature and nature's lighting, Obviously, there are different ways of approaching this problem.

First, let us consider the three cases in which we represent the highest tone of our subject by transparent celluloid and the darkest tone by the blackest deposit of silver of which our print is composed.

The first case is that in which all the tones of nature are more or less equally compressed in the scale of the print. The highest light is white, the deepest shadow black, and the middle half-tone is a medium grey in the print. This is the ideal negative of the technician. It corresponds to a negative which, allowing considerable latitude in exposure, has received normal exposure and normal development. The result evokes no blame and little praise. It is more or less impersonal and unexciting, and is usually of more topographical than artistic interest.

The second case is that in which the shadow gradation is long and extended, and the high light gradation compressed. This form of treatment is suitable for subjects in which the greater part of the picture is composed of dark objects. To some extent it sacrifices the high lights to the shadows. It corresponds to very full exposure and suitable development. The negatives are good printers. It gives results of solidity and richness.

The third case is that in which the scale of gradation is extended in the high lights and compressed in the low tones. It is suitable for subjects whose charm is in their luminosity and the delicate modulations of their lighter tones, for effects of sunlight on light surfaces. It sacrifices the shadows, and, if these are extended, makes them look empty. It corresponds to careful development with comparatively short exposure.

In these three cases we have postulated the existence of gradation sufficiently contrasted to give both black and white in the prints. But actual white is found, as a rule, only in small patches in nature—as the highest light on a sunlit cloud or white object—while absolute black is practically non-existent.

Now, though the black of a print is not comparable with actual blackness, i.e., absence of light—yet we know that it is the blackest black we can obtain on a print. If we use such a black to represent something in nature which is not absolutely black, the print will appear forced and exaggerated.

In nature we feel that there is always a reserve. Though the dark shadow in nature may be much darker than the black on our print, yet we know that in nature still deeper tones exist, while in the print we have touched bottom. For this reason it is safer not to use quite the full gradation of a printing paper, or if we use it, be careful that white and black appear only in very restricted areas, to form the extreme accents of the high light and deep shade.

From the foregoing it will be seen that we do not always utilize the full scale of gradation, but may vary the expression of pictures by adopting a high tone in which we have full gradations in the lighter portions of the picture and no darks, or a low tone with full gradations in the shadows, but no lights.

Obviously, in neither of these cases must development be pushed so far as to get a very long scale of gradation. In the first case the exposure must be comparatively short, in the second, sufficiently prolonged to give the shadow tones.

Such a restricted scale is most appropriate when we wish to give an effect of great luminosity or of gloom. Although such treatment is capable of giving a very good illusion of certain aspects of nature, the results are more likely to appeal to the few than to the "man in the street," who prefers more full-blooded presentments of nature.

The general design or composition of a picture, and its masses and light and shade, are of paramount importance. Detail is good if it helps to emphasize and increase the interest of the general idea, but bad if it attracts attention from, or conflicts with that idea.

For instance, if in a picture, the eye, following some attractive line from the foreground, halts to consider the principal object in the middle distance, and finds pleasing detail there, the sensation is one of added enjoyment. First the good design, then the pleasant progression, then the interest of the main object, and then the further interest of examining its details and finding fresh beauties. This is a right use of detail.

When, on the other hand, detail, whether owing to too crude lighting or to too sharp focusing, is sprinkled all over the picture, and draws the eye now this way, now that, then it is detail incorrectly used.

A picture may be sharp, or nearly sharp, all over, yet if the details are subsidiary, and do not flaunt themselves, the effect may be harmonious—witness many of the paintings of the pre-Raphaelite school. On the other hand, a picture may have no sharp place in it, as in the paintings of the French Impressionists, and yet be harmonious.

There is no general law, only the rule that detail must be subservient to the general idea of the picture. Detail may be considered as pictorial embroidery—rightly used it gives a rich effect, wrongly used a garish one. Yet, as we may have a beautiful drapery either with or without embroidery, so we may have a beautiful picture with or without detail.

In a photograph we are more likely to have too much than too little detail. Often it is a case of not seeing the wood for the trees. If we focus sharply on our principal object, we shall get other objects in the same plane sharp also.

It is one advantage of the older forms of lens that their curvature of field, or their marginal astigmatism, partially eliminates the detail round the edges of the picture, where it is most likely to be superfluous.

The larger the stop used, the fewer planes are in focus at the same time, and for this reason one should work with the largest stop with which fair definition is obtainable, focusing generally on the principal object or on the foreground, for a blurred tree or rock in front of the picture is objectionable, while a diffused distance is generally pleasant. If we stop down too much, we lose all effect of relief and distance, unless, indeed, nature has been so kind as to intervene with an evening mist to soften the distance for us. We are using too large an aperture, when the drawing of objects is lost.

A certain amount of detail is probably necessary to convey texture, but in landscape this is not always requisite. Less detail is necessary to indicate the shape of objects. When form is lost by extreme diffusion, we attract attention to parts of the picture which it was our intention to keep subsidiary.

Depth of focus, or depth of definition, the name given to the power of a lens of defining equally sharply, planes at different distances, is chiefly a matter of focal length and stop.

Using the same lens, the depth of focus is increased by stopping down.

Of two lenses of different foci working at the same relative (not actual) aperture, the shorter focus one has the greater depth of definition.

A great softener of detail and harmonizer of tones is the atmosphere, especially if burdened with moisture, not necessarily in the very distinct form of mist or fog.

We sometimes notice how hard and crude everything looks in an east wind, how black the shadows are, yet how devoid of that mysterious depth which is so attractive to the artist. That which is lacking is "atmosphere."

The effect of atmosphere—aerial perspective—is to interpose, as it were, a light veil between object and spectator. Only near objects are visible in their real tones or values, those further away, are more and more veiled as they are at greater distances from the eye. The effect of this is twofold. On the one hand, it blurs and diffuses objects progressively, according to their distance. On the other, it confounds their color or tone, by shrouding and covering them with a veil of mist. Thus a black and white object near at hand becomes but dark and light grey when we recede from it, while from the distance it appears a uniform grey tone.

It is one unpleasant effect of under-exposure and over-development that they tend to exaggerate the contrasts of distant objects and make them come forward, "jump," as it is called.

In order that the different tones of a picture should appear to the eye at their right distances, their values must be correct, that is to say, they must be to some extent proportionate to one another. The tones individually need not match the tones they represent in nature, but they must bear a similar relationship.

Thus, we may represent a light tone in nature by a light tone on developing paper, or by a medium tone, and both may give a true effect if all the other tones are shifted down in correct relation.

It is not known whether this question of values can be accurately proportioned or scientifically measured. The problem has been attempted, but not solved. At present a trained eye is the only judge.

It is therefore necessary to carefully educate one's taste by observation. It is the only safeguard against those crudities of tone which are far too frequent, even on exhibition walls. Nevertheless, we are progressing in that matter, faster perhaps than in other directions.

The ordinary photographic film is color blind, and therein lies one of the chief causes of false values. A blue object appears too light, and a yellow object too dark when the negative is taken on an ordinary plate. The ordinary film is little affected by pure spectrum yellow light in the time required to impress the blue rays; yet as all objects in nature reflect mixed colors, including a good deal of diffused white light, and not merely a single spectrum color, this insensitiveness is less formidable than it would otherwise be. Nevertheless, it is quite sufficient in many cases to entirely falsify results. I have, for instance, taken a field of blossoming gorse on an ordinary film, and the result has shown no indication of blossom. All photographers, too, know the difficulty experienced in obtaining clouds on the same plate as the landscape.

Orthochromatic or isochromatic films are prepared with a dye, which enables the film to absorb, and be affected, by rays of color which the ordinary film fails to hold fast. There are two chief classes of orthochromatic films—the one class sensitive to yellow and green, the other sensitive to red as well.

The latter, or panchromatic class, is rather difficult to work,

*(Courtesy of the International Film Service)*

U. K. WHIPPLE, STAFF PHOTOGRAPHER OF THE INTERNATIONAL FILM SERVICE, ON HIS WAY THROUGH THE ALPS TRAVELLING FROM PARIS TO ROME WITH PRESIDENT WILSON'S PARTY.

fogging easily, and hardly permitting development to be watched, and therefore most suitably developed by time. The other class, with ordinary care and by using a good red light and shielding the tank during development, is nearly as easy to work as ordinary film. Yellow being to the eye the brightest color, it is yellow sensitiveness which is important, and so red sensitiveness is to some extent a luxury.

Whichever class of film is used, however, its blue sensitiveness is still excessive. In order to make full use of their orthochromatic properties, it is necessary to damp the blue and violet rays of the image with a yellow or orange screen. These have already been discussed.

By a suitable screen, in conjunction with an orthchromatic film, it is possible under favorable circumstances to obtain the sky and landscape both well rendered on the same plate. When a dark foreground is contrasted against a bright sky, it is, however, a difficult matter to expose so that both landscape and sky are satisfactorily rendered. It is well worth trying, though one may have to put up with frequent disappointments.

After selection, which settles the composition of the picture, and focus, which decides its detail and to some extent its emphasis, we arrive at the very important matter of exposure, which, with suitable development, decides its tone and gradation. The old idea was that you could give almost any exposure, and then make up for its incorrectness by suitable development.

The modern trend of opinion is almost the contrary. Once the exposure has been made it is only possible to alter contrasts by giving a short or a long development, or, what is much the same, a weak or a strong one.

Modern authorities do not deny the value of bromide in over-exposure if used from the beginning of developmpent; but as its use in quantity appears to be equivalent to slowing the film, it is hardly suitable for unknown exposures which may have erred on the short side.

Whether we believe in the possibility of modifying results or not in development, however, we cannot help believing in the importance of exposure. For this reason it is necessary to have some guide which will enable us to estimate, or rather approximate to, a correct, or preferably a normal exposure.

Once we know what the normal exposure is, it is possible to modify it in either direction to obtain special effects, as suggested when discussing tone gradation; but if we only guess at the exposure, we are working in the dark mentally—a far more difficult task than working in actual darkness.

Given a normal exposure on an ordinary subject, we shall get good gradation; the length of the scale and the amount of contrast depending on development.

With under-exposure we shall get either a partial scale without contrast, or an abrupt scale with contrast, according as we develop little or much.

Normal exposure may be defined as the exposure, which, with normal development, gives detail in the shadows without overexposing or blocking up the lights.

The principle on which exposure is calculated is simple, though the estimation itself is not always easy. If we always took similar objects in the same light, with a particular film and stop, we could always give the same exposure.

It is the variation of these four factors, stop, film, light and object which modify exposure.

The basis of all methods of calculating exposure consists in taking an exposure which has been proved to be correct as a starting point, and multiplying or dividing it to compensate for alteration of the four factors.

To take the simplest factor first. The stop lets through light in quantity proportionate to its area; and its area is proportionate to its diameter squared. Thus a two-inch stop lets through four (that is, two square) times as much light as a one-inch stop, and therefore requires only one-quarter the exposure. Simliarly f/12 requires four times the exposure of f/6.

With different lenses, the equivalent, not the actual aperture, is the measure of the light passed. Thus f/8 must be taken as of equal rapidity with all lens.

The next factor is the film. Its speed must be found by trial, under known conditions, or taken from one of the published lists.

The most difficult factor is the light, and this must either be measured with an actinometer, or taken from tables giving its strength under different weather conditions in different latitudes and at different times of the day and year. If we use tables we must have another factor for subject, for obviously the exposure for an average landscape will be much shorter than for the interior of an avenue. When the light is directly tested, this subject factor may be eliminated for ordinary subjects. In the shade of an avenue, for instance, the actinometer will darken much more slowly than in the open.

The tabular method is exemplified in the Hurter and Driffield meter; in the Photographic Era exposure table; and is elaborately worked out in the Burroughs and Wellcome exposure record. The actinometer method has been perfected by Watkins and by Wynne.

Theoretically the actual testing of the light is most correct. In practice, all methods give very similar results.

Most films possess great latitude in exposure. If the normal exposure be doubled or halved the difference would generally not be great.

This latitude of a film is more severely taxed when the subject includes great contrasts than when there is a short range of gradation. Considerable latitude is necessary to correctly render a bright cloud and a dark, detailed shadow at the same time. In such cases, therefore, careful exposure becomes a necessity. Careful development, too, is necessary, or the sky will be so dense that it will not print out till the shadow detail of the landscape is buried. On the other hand, subjects of slight gradation may receive exposures in the ratio of one, two, and four on separate pieces of film, be developed for the same length of time in the same tank, and yet give prints indistinguishable from one another, though the negatives will be different in density.

It may be well to sum up shortly the different qualities on which depend the artistic values of a picture.

From the point of view of natural effect, the most important are tone and values; from the decorative standpoint—good design, including spacing, balance, line and mass; unity, the subserviency of all parts of the picture to the general effect and idea of the picture; and harmony, which pleases the eye by good light and shade, with absence of clashing lines or harsh contrasts.

The artistic expression of the picture depends on all these, its moods depend on key, on focus, on contrast, and on line. It depends also on the photographer, on his seeing eye, on his capacity for discovering and being impressed by the beauties of Nature; finally, on his ability to record something of these beauties and something of his emotion in receiving them, so that those who behold his picture may see and feel with him.

## Chapter XIX

# AIRPLANE PHOTOGRAPHY

THE tremendous increase of interest in aeronautics brought about by the war has brought the importance of aerial photography to a prominence which cannot be ignored in a book on motion photography.

Already many of the large producing companies are maintaining hangars and fleets of airplanes for taking motion pictures in the air. Dare-devil stunts on terra firma have been worked with every conceivable variation and permutation until the spectators have become blasé and view with ennui, feats that thrilled them to the marrow a few short years ago. Consequently, producers, ever alert for new sensations, have turned with alacrity to the possibilities of new hair-raising stunts performed thousands of feet in the air.

In most of the stunts on the ground or even on the water, the cameraman often shares to a large extent the dangers involved in the feats depicted, but in only a fraction of a degree to what he must share in taking stunts in the air.

In working on the ground with speeding trains, or other racing vehicles he can easily reduce the speed of the moving participants and by reducing his cranking rate produce the effect of breakneck speed, whereas the apparently wildly careening machines are in reality proceeding at a leisurely pace.

In the air, however, no such latitude is permitted him. His racing airplane cannot reduce its headlong flight without falling to the ground and his crank hand must never falter or lose a stroke even though he hang head downward with ten thousand feet of thin air between him and the good green earth. Not only must he keep cranking but he must also panoram with lightning speed to retain his subject in the field of his camera. The constant shifting of the planes in the unstable air make it impossible to get the picture without giving a contortionist cards and spades and beating him out at his own game.

The work of a cameraman in a ship is analogous to that of a machine gunner in a combat plane. All planes are "ships" to

(*Photo by U. S. Signal Corps*)

MADISON SQUARE AND METROPOLITAN TOWER, NEW YORK CITY, FROM THE AIR

the aviator and the science of aviation has given us a new vernacular which we may presently find blending its picturesqueness with the idiom and *patois* of the picture game.

The writer, who happens to be the editor of this book as well, feels, with considerable egotism perhaps, that he can write with some authority on the subject, as he made for the Department of Military Aeronautics, while in the Army, several thousand feet of motion picture film while in the air. In addition he made sundry flights at other times for other purposes including ascensions in balloons, both free and captive; dirigibles, observation and kite balloons, airplanes of many types and flying boats.

In all of his experience of more than twenty years of photography in many lands and different climes, he found nothing—not even three months' exploration of coral reefs on a tropical sea bottom in a glass-sided diving bell—which can begin to compare with the pleasurable excitement of aerial photography.

Taking a flight as a passenger securely strapped in the seat in the observer's cockpit and protected from the rushing air by the sides of the fuselage is like riding in a limousine, compared to standing behind a camera with half the body exposed to the ripping, tearing, raging hurricane from the propeller, whipping past in a hundred-and-twenty-five mile gale with the roar of the exhaust battering the ears till your loudest shout becomes but the shadow of a whisper to your own ears.

If you have no gosport or speaking tube to communicate with your pilot, it is necessary to arrange a system of signals before ascending so that you can direct him as to what to do.

Much of the success of your pictures depends upon your pilot's having a good camera sense. Fortunately most good pilots have an inherent sense of distance and after being shown just what angle the camera covers, will be able to keep the camera ship in the most advantageous position and at the correct distance.

In a machine where the cameramen can be stationed in the observer's cockpit forward of the propellers, the work is a cinch compared to the more common two-seated tractor where the photographer must take the rear seat and the full blast of the propeller. In a ship or a flying boat with a forward cockpit the camera can be trained easily in almost any position and close-ups may be taken of the operation of the ship itself.

With the tractor type in which the cameraman must work in the rear cockpit, it is generally impracticable to shoot forward at all, the range of view being limited to the sides and over the tail. I have worked in ships that were in such bad repair that they threw a constant spray of oil and water from the engine and radiator back onto me and the camera. Turning the lens toward this was, of course, out of the question.

On the other hand, I have been in some ships which were so clean that the camera could be turned directly toward the propeller and operated for minutes at a time without fogging the lens. The revolutions of the propeller are so swift that it is seldom that they interfere with the picture unless the sun strikes the blades at an angle which throws reflections into the lens. So do not hesitate to shoot through the propeller blades if necessary. Naturally in shooting in any direction except at right angles to the fuselage of the ship in a rear seater, portions of the plane will show in whatever view is being made. Generally this adds to rather than detracts from the picture. However, as dramatic pictures come to be taken more and more from camera ships such obtruding parts will become unwelcome as detracting from the main action of the picture and more care must be exercised to see that these extraneous parts do not intrude in the field of view.

The pilot has almost as much to do as the cameraman in obtaining stunt pictures, that is, close-up views of other ships flying near the camera ship. Besides keeping at a proper angle and distance, there is the problem of flying the ship smoothly so that the taken view will not meander all over the screen. Some pilots have such a delicate sense of balance and orientation that they can dip and bank and put the ship into almost any position without a jar or quaver, while others make it difficult to stay with the camera, to say nothing of being able to crank it.

An expert can wing a ship over into an almost vertical bank and turn at just the right curve so that the gravitational and centrifugal forces just neutralize each other, and though the cameraman may be standing with his body almost horizontal and be shooting straight down vertically over the side, yet in relation to the plane, he is standing straight up and not touching the side of the cockpit. Instead of fearing that you are about to drop out of the plane, the sensation is not that you have turned half-way over, but that the earth has suddenly gone crazy and tilted itself up on edge and that the only way that you could drop out would be to fall through the bottom of the plane which seems still to be in the direction of down. In a like manner in looping the loop, when it is done at just the right speed, the earth tilts up at the tail of the machine, rises up, sails over your head, drops down in front of the propeller and then resumes its customary place beneath you.

Don't go up if you are not feeling well. Even a good aviator will not do that. I did it once and it made me very sick. I do not feel ashamed to tell it for half the pilots on the field would not go up that day. It was at one of the Texas flying fields where the officers' mess was fortunate in having a particularly good cook and the evening before, fried liver and bacon had been the *piece de resistance* at the eating club and although it certainly tasted good, all who partook of it had a strong touch of ptomaine poisoning. I was one of those who had eaten heartily of it and had passed a bad night in consequence. Still, a special aerial combat had been arranged for me to record and I did not feel that I could refuse after elaborate preparations had been made to engage the best pursuit pilots for a mock battle in the clouds.

My own ship was manned by a fine stunt pilot and his instructions were to fly just above the combat planes who were to play hide-and-seek in the clouds below. Well, I'll say we did a few stunts ourselves trying to keep those two pursuit artists within camera range and get their swoops and feints and starts and dashes at each other. They did everything in the aviation decalogue and a few more that haven't any names with my pilot trying to step on their tail and me humping to keep them in the camera.

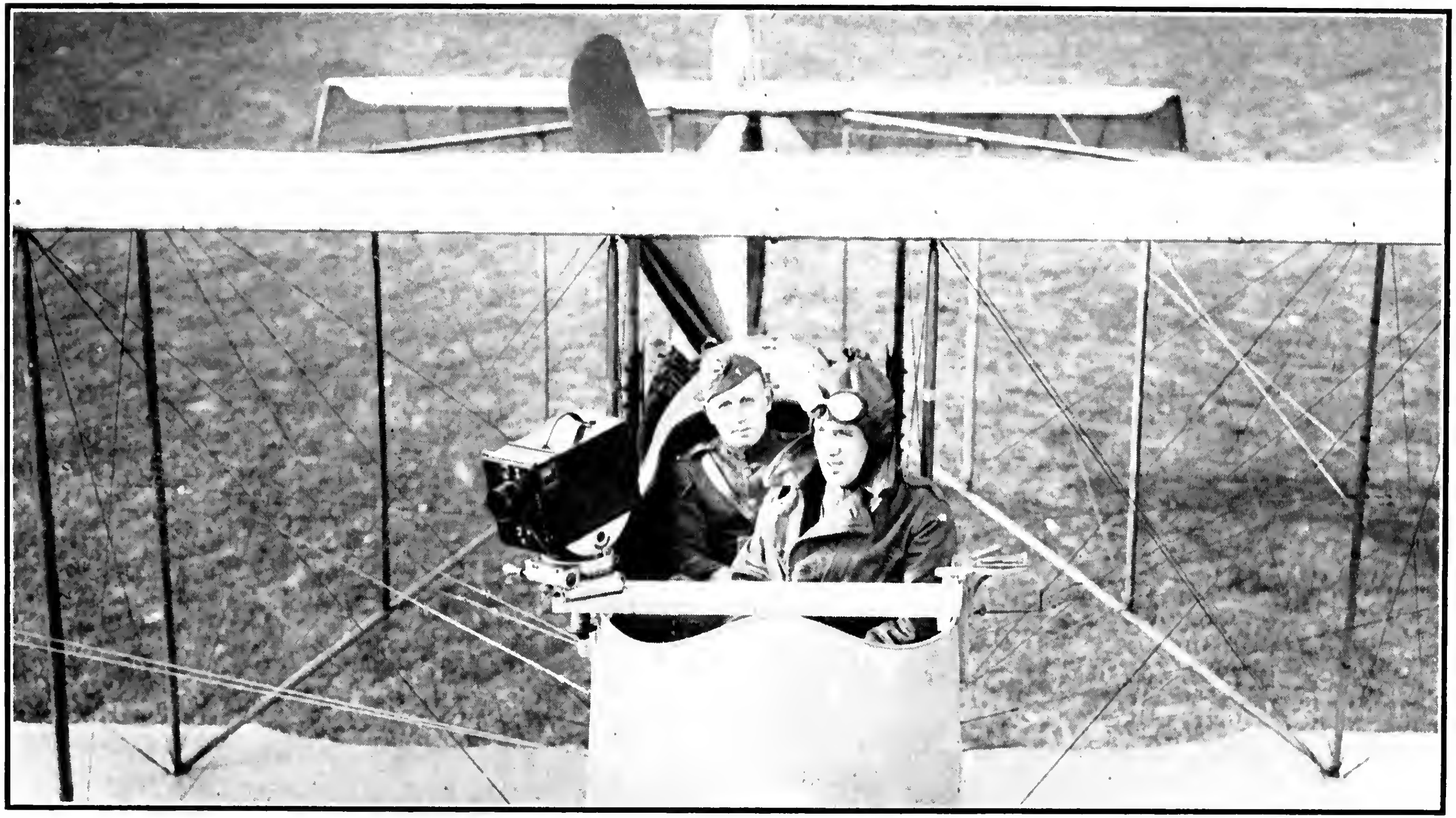
Well, I got four hundred feet, all there was in my magazine and signaled the pilot to go down. He turned around at my touch on his shoulder and he must have seen my pea-green complexion for he didn't lose any time getting down into the field which was fortunate for I had a severe attack of sea-sickness. The pilot, who had also partaken at mess the evening before, was very polite and was similarly affected. He was in fact apologetic and said something about a weak stomach so that I couldn't help rejoining that he had a pretty good one; he seemed to be shooting about as far as I was.

The main secret of taking good pictures from an airplane is in having the camera securely fastened to the ship so that the vibration cannot loosen it. When a machine-gun ship can be used, the machine gun scarp makes an ideal mount. With the machine gun removed, the average tripod head with the legs removed can be fastened to the mount with a single bolt four or five inches long and ⅜ inch in diameter with a sixteen thread. A ⅜-16 bolt fits the regulation tripod socket. With the scarp mount the camera can be trained instantly in any direction and does not take up much room in the cockpit and the swivel seat and gunner's belt will also prove useful.

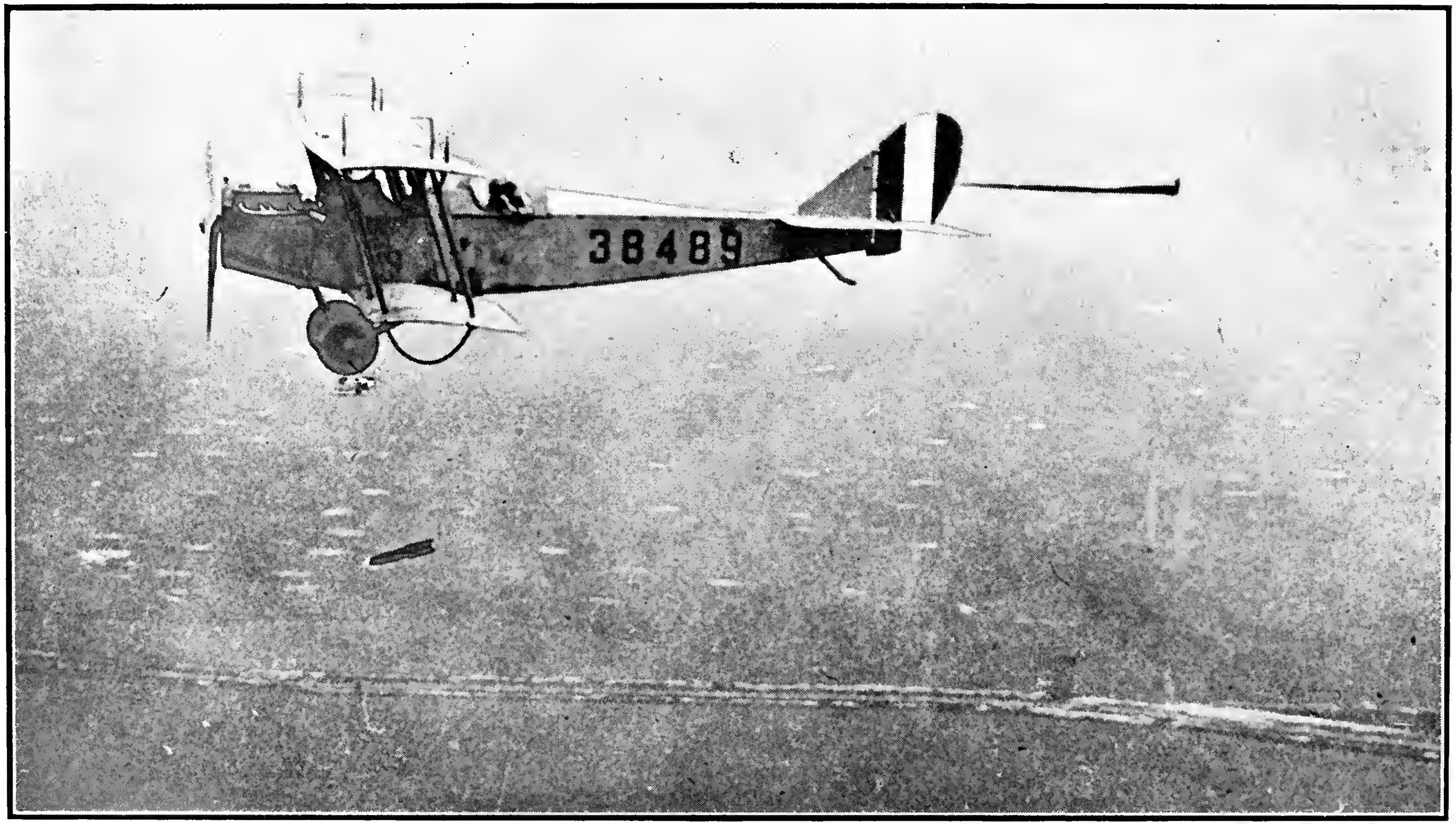
Where a machine-gun scarp is not to be had, a mounting device can be made easily in almost any ordinary repair shop. This consists of 6 in. or 8 in. boards just long enough to fit under and over the upper longerons across the cockpit. Two holes are bored near each end of the boards and one in the centre, the boards being placed in alignment and bored at the same time. Four bolts through the end holes will clamp them firmly to the longerons which are the two upper main members of the fuselage frame running lengthwise of it. If it were not for the rounded cowl on top of the fuselage, the tripod head could now be bolted directly to the clamp through the centre hole in the boards. The cowl, however, interferes with the manipulation of the camera and renders it necessary to place enough blocks under it to raise it above the cowl. These blocks should be six or eight inches square with a hole through the centre of each. A king bolt must now be made of ⅜-inch rod, long enough to pass through the clamp boards and the blocks and screw into the tripod socket. Large washers should be placed on the bolt heads and under the nuts so that everything can be tightened up firmly without drawing the bolt heads into the wood. Thread the king bolt for a good distance at each end for the block and boards will stand considerable compression before they are perfectly firm.

Now see that everything about the camera is in perfect shape and securely fastened. The turning handle and the tripod handles must be fastened on their spindles or the vibration will shake them off and cause you to lose them.

A light yellow ray filter should be used. This you can well afford to do because in airplane photography you have the ad-



LT. HAROLD A. C. SINTZENICK, S. C., U. S. A., READY FOR FLIGHT IN AN ENGLISH PLANE.




(*Photo by U. S. Signal Corps*)

BOMBING PLANE SHOWING DROPPING BOMB.

vantage of all the light that there is. Even with the Eastman filters $K_1$ or $K_2$ pictures can be taken at f 8 and f 11.

Set the lens at infinity unless you have fairly close up pictures of other planes, in which case, set it at thirty feet which, at the aperture you are using will render everything beyond 6 or 8 feet perfectly sharp.

Use the shutter wide open. It has been advocated that a narrow shutter opening should be used so that the sharp definition of a quick exposure would neutralize the effect of vibration. This is a fallacy. If vibration is severe enough to spoil single pictures, it will spoil a series also. Even though each individual frame may be sharp the succession of sharp pictures out of register with one another will be blurred on the screen and show a greater effect of vibration than when made with an open shutter and small stop.

In cases where it is not possible to make a special camera mount for a ship, the tripod can be lashed in the cockpit with strong twine and straps but this should be done only when no mount can be obtained. The legs are bulky and take up useful space in the cockpit and it is almost impossible to fasten the tripod so that the panoramic head will be level with the plane.

See that your flying clothes and goggles are fastened securely but comfortably. Losing your goggles will mean loss of sight for as long as you are up you will not be able to open your eyes in the terrific blast from the propeller. Fasten your clothes tightly or the air will balloon them and they will interfere with camera operation.

## Chapter XX

# HOW SUBMARINE MOVIES ARE TAKEN

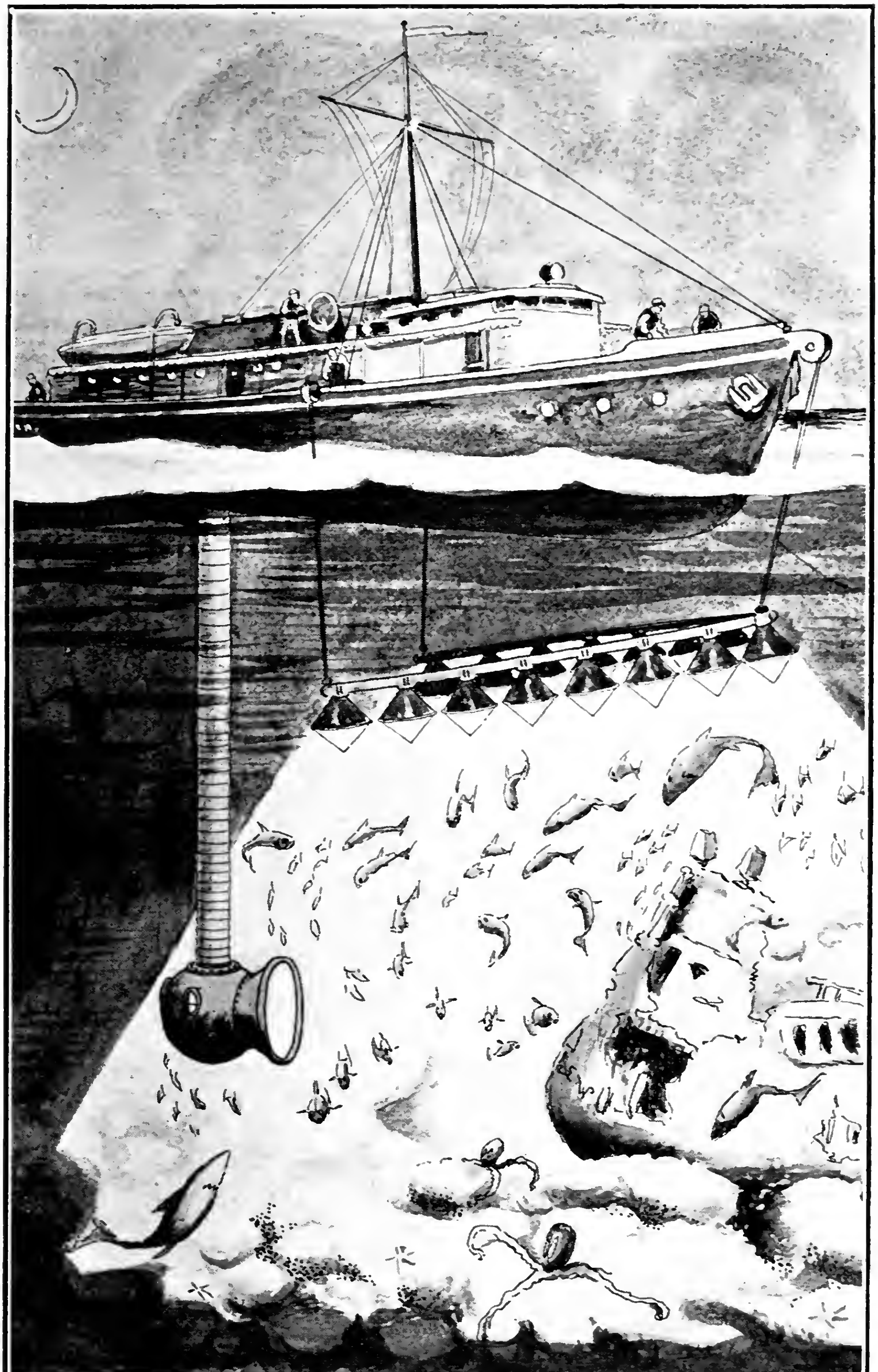
Written by Lu Senerens

Captain Charles Williamson, of Norfolk Va., perfected an invention several years ago designed to explore the bottom of the sea. The apparatus consists of a barge, a flexible tube of metallic construction, and a submergible terminal operating chamber, containing a steel cone projecting outward, the end of which is made of glass. By descending the tube into the sphere and photographing through the glass, pictures of submarine life can be secured.

The inventor's sons, J. Ernest Williamson and George M. Williamson, helped their father in the development of the apparatus. They began experimenting with ordinary cameras, and secured some excellent snapshots of fish at the bottom of Hampton Roads. This experimenting led them to the belief that Moving Pictures of submarine life could be taken, and they formed a corporation of Norfolk business men.

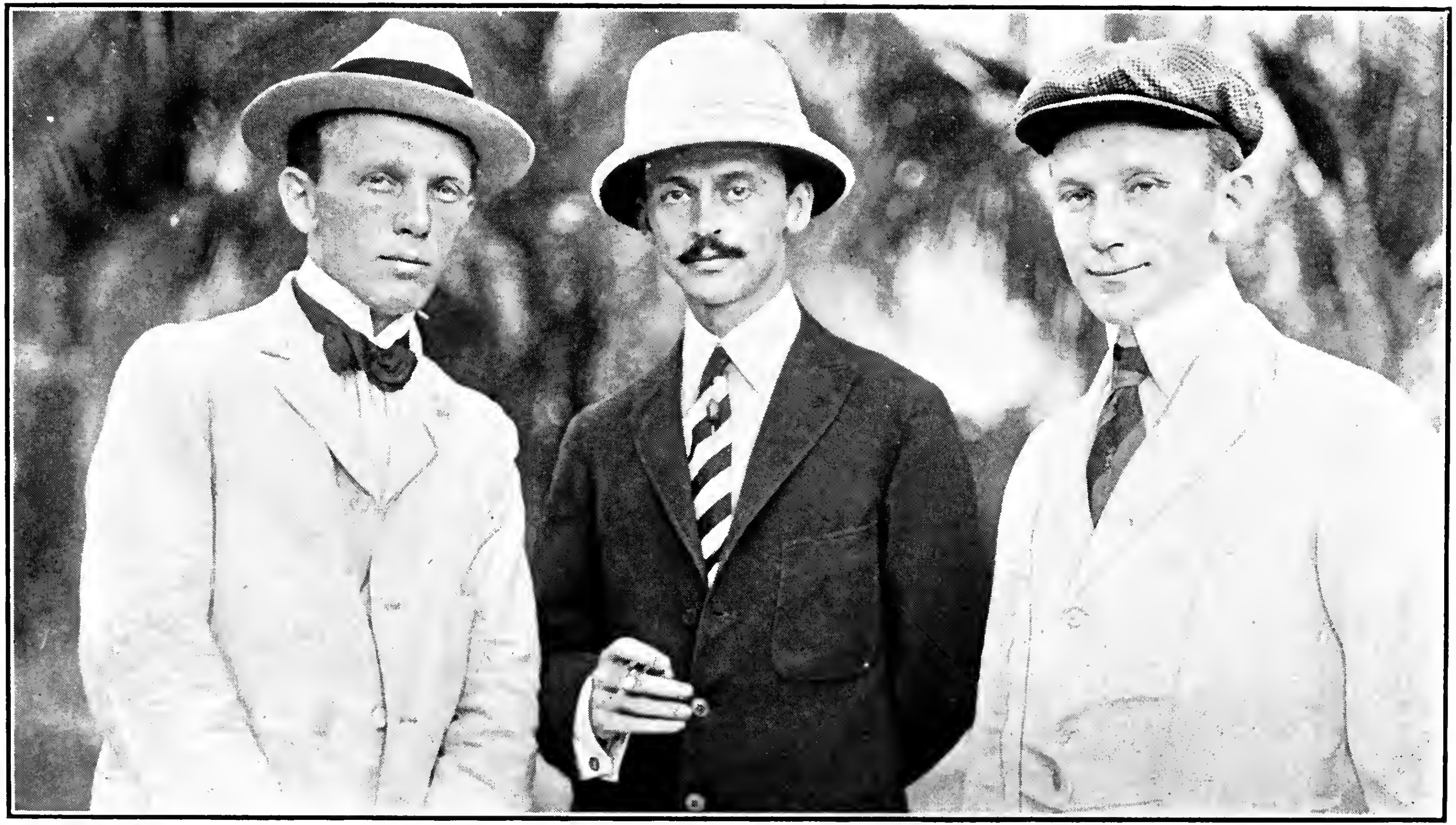
An expedition was then planned to take the apparatus to the West Indies. The photography was in the hands of Carl L. Gregory. The famous marine gardens of the Bahama Islands, near San Salvadore, were selected as the best location for the first under-the-sea studio. This location was chosen because of the remarkable clearness of the water and the variety and beauty of animal and vegetable life. A vessel suitable for operating the apparatus was constructed in the shipyard at Nassau, in the Bahama Islands. The marine gardens nearby were selected as the place for taking the first pictures. This location is more beautiful than any other in this part of the world. The sea bottom is strewn with wrecks along the treacherous coral reefs, and the denizens attain the most gorgeous colors and most fantastic forms.

Here Mr. Gregory secured a panorama of the sea bottom by the perfect illumination afforded by the sunlight coming down through the water and striking the white coral reefs. It required ten days of experimenting and considerable waste of film to ascer-



*(Courtesy of the Submarine Film Corporation)*

DIAGRAMATIC VIEW SHOWING THE MANNER IN WHICH UNDERSEA MOVIES ARE MADE BY THE USE OF THE WILLIAMSON DIVING TUBE AND SUBMARINE PHOTOGRAPHIC CHAMBER



*Armbister photo*

Left to right—J. E. WILLIAMSON, CARL L. GREGORY, GEO. M. WILLIAMSON.

tain the correct exposure necessary for submarine photography. Some of the pictures were made at night with the aid of submarine lamps equipped with 2,400 candle-power Cooper-Hewitt quartz burners. The exposure for day and night pictures was about the same, the average being from one-thirty-second to one-seventy-fifth of a second at depths varying from 15 to 60 feet.

Scientific photographers in America had previously declared that no practical photographs, much less motion pictures, could be obtained under water, but the result of the expedition of several months' duration was about 20,000 feet of moving-picture film. These pictures were later produced and copyrighted by the Submarine Film Corporation.

Mr. Hadden-Smith, the colonial governor of the island, was much impressed by the importance of the work. Both he and his wife descended into the observation chamber, and were amazed by the beauty of the spectacle revealed.

A series of scenes native to the Bahamas were fixed upon and photographed. For example, all tourists in tropical waters have seen negro boys dive for coins thrown into the water. Perhaps one of the most intensely interesting scenes in the film is the one showing these negroes beneath the surface fighting each other for the descending pieces of silver. As many as three at a time were caught by the camera struggling to secure the money at a depth of about 25 feet from the surface.

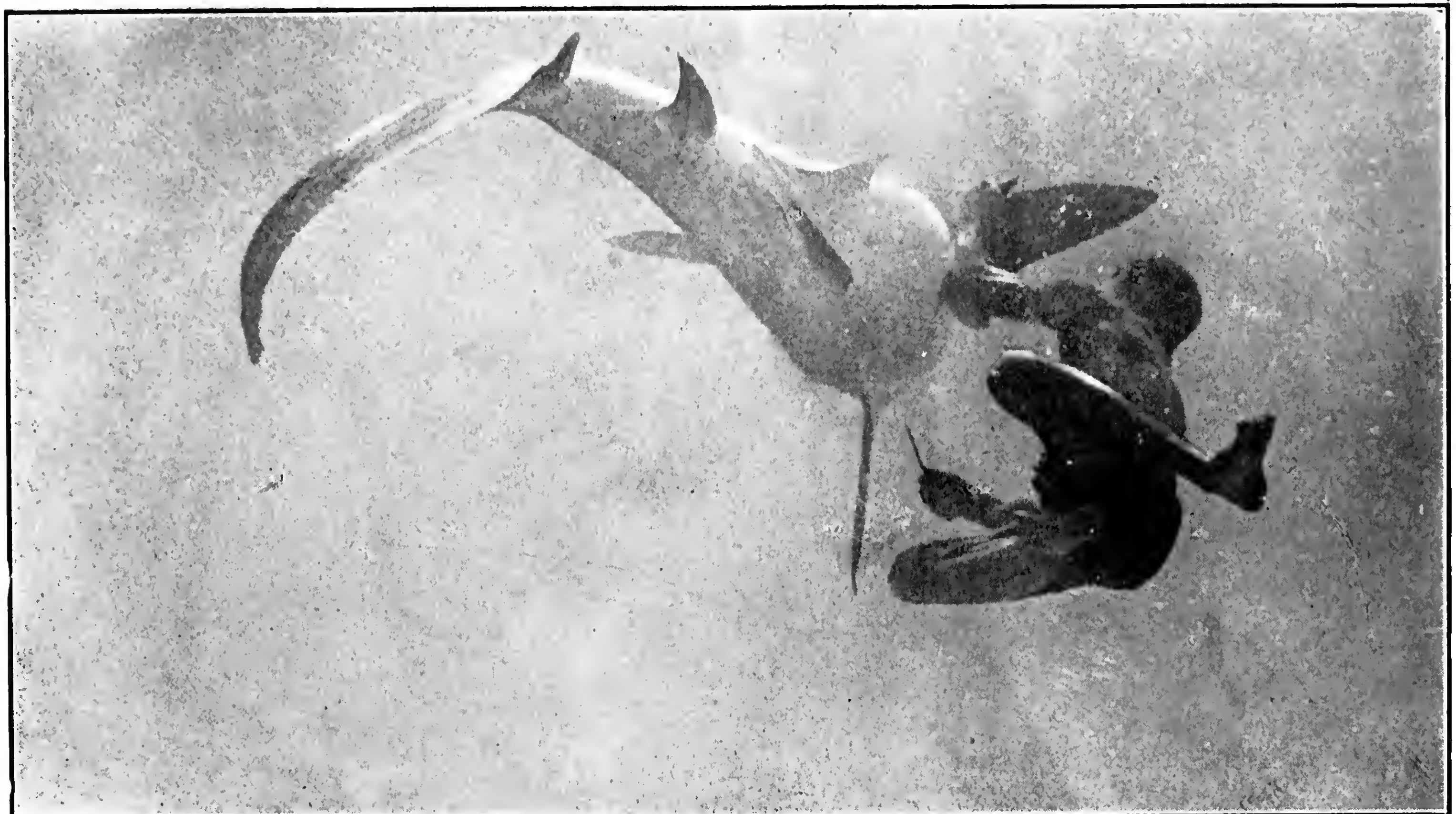
Not far from Nassau lies the bulk of an old blockade-runner, wrecked while seeking safety in that harbor at the time of the Civil War. She sank to a depth of 50 feet, and her location was well known. As the expedition required a scene showing a diver under water, George Williamson volunteerd to enact the rôle and a diving suit was borrowed from the colonial government. Mr. Williamson had never been beneath the surface in such an apparatus before, yet unhesitatingly donned the suit, made the descent near the wreck of the blockade-runner and strolled about picking up cannon-balls. These were sent to the surface in a wire basket at the end of a rope. His movements were photographed by Mr. Gregory from inside the spherical chamber.

Numerous exposures were made of the great variety of fish frequenting those waters. A number were snapped swimming about their natural haunts among the coral reefs. Some were drawn near the aperture of the photographic chamber by means of a baited line. In many cases color plates were taken of the finny beauties as a guide for coloring the film by hand, so that the public might see the creatures in their tints.

Man-eating sharks are indigenous to the waters of the Bahama Islands, and a film that has no counterpart in the annals of photography was made of a battle royal between two of these leviathans. Some of the monsters are from 18 to 20 feet in length. In order to secure this film the carcass of a dead horse was towed out to sea and anchored in the water near the Williamson apparatus. It was then cut with a knife in order that its blood might attract sharks to the spot. Within an hour there were fully twenty-five of the monsters nibbling at the bait. An effort was made by the crew of the barge to catch some of the sharks with hooks, to which heavy woven wire was attached, but they snapped the wire with their teeth, and it then became necessary to use chains. One of the largest of the sharks was drawn close to the observation chamber in order to secure a photograph of his struggles. He retained a large piece of meat in his mouth, which attracted another shark, who came up to wrest it from his jaws. The second shark, angry at its inability to get more food, dashed away into the abscurity like an enraged lion, but returned and with open jaws darted like a bull at the one held fast by the hook. The photograph shows his snatching at his companion's huge fin, and he is seen tearing it to shreds with his serrated teeth. The captured shark in turn became furious, and began swimming around wildly in an effort to get at the other.

Alarmed for the safety of the photographer should one of these raging monsters burst in the glass, the man on deck slackened the line, and the sharks began to sink below the observation chamber. They were plunging toward each other with wide-open mouths, tearing at each other's body until they were reduced to shreds and a mass of streaming blood. Despite the fact that one of the fish was handicapped by hook and chain, it beat off the other and won the battle. It was later drawn to the surface and killed.

The most daring feat ever attempted by a moving picture actor was one undertaken by Mr. J. Ernest Williamson. Stripped to the waist, a knife between his teeth, he dove into the ocean where a dozen man-eaters were making the water fairly boil in their mad



(*Copyright by Submarine Film Corporation—Photographed by Carl L. Gregory*)

NATIVE DIVER IN SINGLE-HANDED COMBAT WITH A MAN-EATING SHARK.

(*Photo by J. F. Williamson*)

FISH AND SEAWEED IN NORFOLK HARBOR. THE FIRST SUBMARINE PHOTOGRAPH EVER TAKEN.

rushes for another victim. Descending twenty feet, Mr. Williamson met an ocean monster and fought his battle of life and death. The photographer, watching the encounter with terror, kept turning the crank and recorded every movement of the desperate combat. Mr. Williamson had taken his life in his hands to fight a shark in order that the scene might be recorded on the moving-picture film. As he went under the water he observed an enormous shark darting toward him and permitted his body to sink under it. The shark shot past over his head and turned just as Mr. Williamson ascended. They were now face to face. The strain of holding his breath nearly thirty seconds was becoming unendurable. He knew that he must kill the shark or the shark would kill him, and it had to be done before his breath gave out. With a quick movement, he swung slightly to one side, just escaping the shark's head, and grasped one of its fins with his left hand. Taking the knife from between his teeth, he thrust it into a vital part of the shark's body again and again. Had the combat been prolonged five or ten seconds, as it threatened to be, he would never have come to the surface alive. The cameraman would have seen him torn to pieces by the other monsters that came gliding around in a circle outside the range of the lens, watching the finish of the fight.

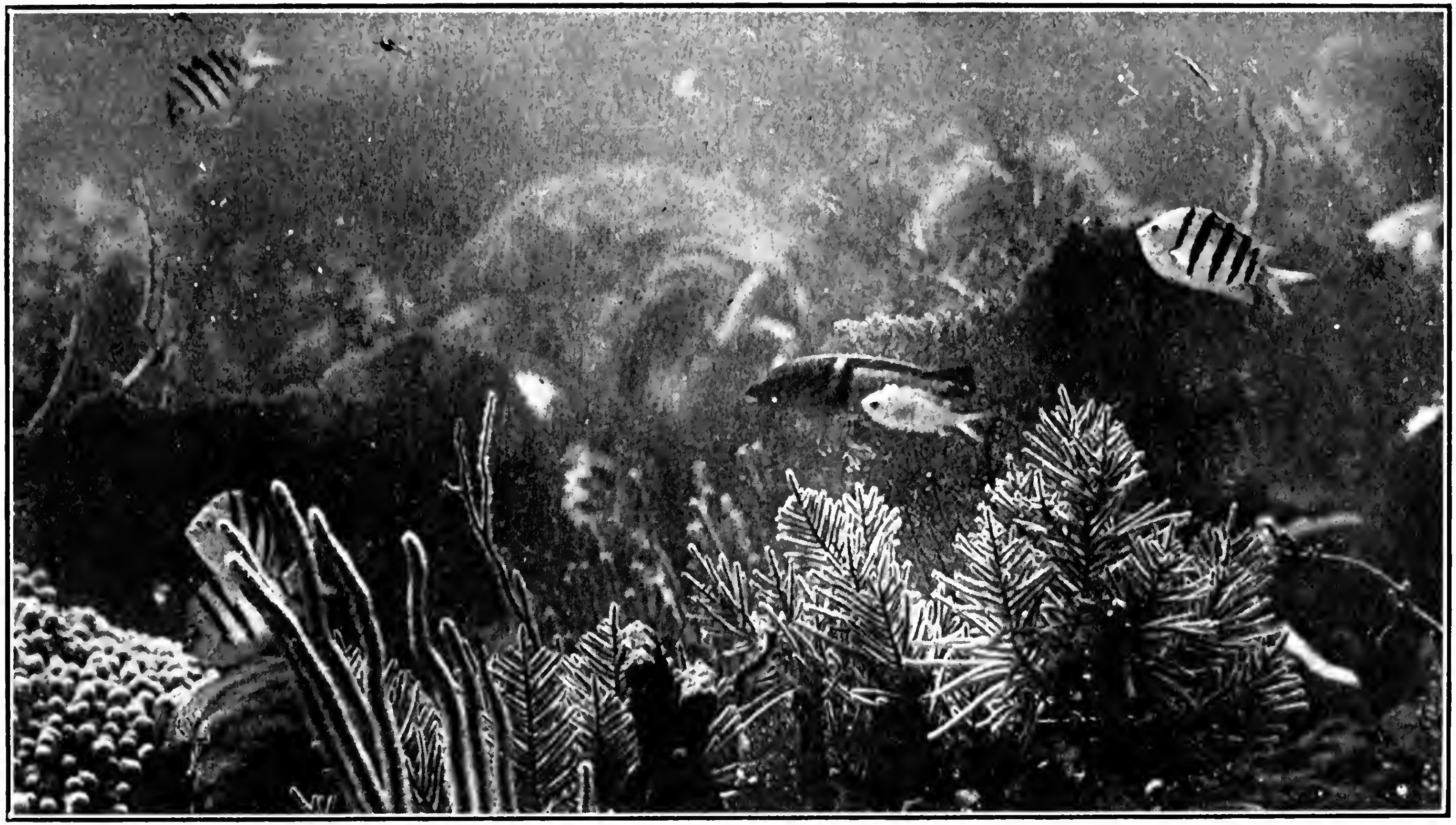
Perhaps his feat was foolhardy, but hardly more so than Orville Wright's first flight in his biplane. Mr. Williamson was simply doing something that no other man had ever done. Once he learned that he could take photographs at the bottom of the ocean, it was up to him to stage at least one picture that would be memorable in moving picture history.

Many other intensely interesting photographs were taken, showing the flora and fauna of the ocean bed, and not the least interesting of the latter is a fish with a turtle-like neck and head. which is a species entirely unknown to the savants of piscatorial records.

Upon the return of the expedition to America, it was decided that the first exposition of the film would be made before an audience of scientists, diplomats and men and women prominent in Washington society. The films were developed and found to be excellent. They were then exhibited in the Smithsonian Institute. Dr. Paul Bartsch, of the institute, mounted the platform after the reels were shown, and, addressing the audience, gave the following endorsement:

"I wish to say that these gentlemen brought us only a few of the astonishing photographs which we have just beheld, and they have shown many times more than we ever expected to see in our lifetime. They have shown us pictures that are the most wonderful and most marvelous ever taken in the world."

The exhibition marked the climax of years of effort and investigation on the part of Captain Williamson to perfect his invention of the submarine tube.



*(Courtesy Submarine Film Corporation—Photographed by Carl L. Gregory)*

CORAL GROWTH AND MARINE LIFE ON A TROPICAL SEA BOTTOM.

*(Courtesy Submarine Film Corporation—Photographed by Carl L. Gregory)*

Diver at work on the remains of a Civil War Blockade Runner. Coral reef and fish in the background.

## Chapter XXI

# MAKING UP FOR MOTION PICTURES

THERE is a great deal too much make-up used in motion picture studios. The primal idea of make-up should be the same as that of the retouching done by a good photographer in making a portrait, i.e., the removal of superficial blemishes. Retouching the multiplicity of small pictures in a motion picture negative is practically impossible and the actor is supposed to arrive at the same result by the more direct method of retouching his face. Since the average actor is used to making-up for the glare of the footlights and to bear inspection only at comparatively great distances, he is apt to forget that in motion pictures the major part of his work is done in the much stronger and differently colored light of day or in the glare of a multitude of arcs and Cooper-Hewitt's with the relentless eye of the camera only ten or fifteen feet away and often much closer.

Up-to-date directors are insisting more and more that make-up shall be natural and not artificial. Some of the studios even put their extra people on the salary list the day they leave off shaving when they require people for "rough-neck" parts. It requires an artist skilled in making-up to put on a crepe-hair mustache or beard that is not palpably false. The director who uses an actor with a bad make-up is only deceiving himself and not the public.

Below I am giving an abstract of a set of general rules for make-up which was made for a well-known studio a short time ago, and a copy of it should be pasted in the top of every motion picture actor's make-up box:

People doubtful of their make-up should submit the same to their photographer for inspection before appearing before the camera.

As a rule too much make-up is used for natural effect.

For ordinary make-up use Stein's No. 2 grease paint over cold cream with enough flesh or brunette powder to avoid shine or varnished effect of grease and cold cream.

Unless of extraordinary dark or light complexion or in case of skin defects such as pimples, moles, pits, freckles, or fine wrinkles, grease paint should not be used—a light application of cold cream with a slight application of powder gives the best results before the camera.

Application of grease paint: Remember that the camera records the back and profile as well as the full face and extend the make-up to the hair at the top, to below the clothing at the neck and behind the ears at the back.

Make-up of the eyes: As a rule it is not necessary to bead the eyelashes. It should practically never be done although it is sometimes advisable for persons with light lashes to darken them with black cosmetique. If you possess heavy black lashes it is not necessary to line the eyes. Others should line the eyes with a very narrow black line placed as near the lashes as possible. People with prominent eyes and plump persons should shade the orbits of the eyes very slightly with black or brown—generally thin persons and those with sunken eyes do not need to use shading. Unless eyebrows are very heavy and well defined it is generally advisable to touch them up with the eyebrow pencil.

The lips: Be very sparing in the use of lip rouge. Remember that red photographs black and that a heavy application of rouge shows an unnaturally black mouth on the screen. Except in very rare cases do not attempt to alter the shape of the lips by the application of lip rouge. It almost invariably shows. Apply the faintest trace, if any, rouge to the cheeks.

Lining: Lining should not be resorted to except in cases where the character of the part absolutely requires it. Lines should be made with dark red or brown and very carefully blended. Directors should take pains to select their characters according to type whenever possible and not require people to make-up out of their type unless in cases of increasing age, or effects of disease, etc., called for by the scenario.

Wigs: Wigs with wig bands coming across the forehead should never be used if it is possible to avoid it. When this is necessary take great pains to blend the band to the forehead to render the junction of band and flesh as nearly invisible as possible.

Mustaches and beards: The technique of a good beard and mustache would require more space than can be devoted to it here. Do not use curly crepe-hair until you have straightened it by dampening and wrapping around a hot pipe or by some similar method. Comb out the straightened hair and build up the beard

(Courtesy of Selznick)

BE VERY SPARING IN THE USE OF LIP ROUGE.

*(Courtesy of the Universal Film Company)*

JAMES J. CORBETT PREPARING FOR THE DAY'S WORK.

or mustache on the face a small lock at a time with the aid of good spirit gum, then trim carefully. If you do not know how to put a beard on properly get assistance from some one who does. Do not fail to use hair colored to harmonize with your own or the wig you are wearing.

Colors: Light blue photographs white and should never be used in motion picture make-up.

Yellow, orange, red and their combinations all photograph dark. Red and black are exactly the same to the camera.

Yellow blonde hair photographs dark, ash blonde photographs light—the more loosely the hair is arranged the lighter it photographs, and different methods of studio lighting also affect the photographic values of hair.

Actors will frequently startle one by coming onto the stage to work in a new and wonderful (?) make-up that someone told them to try.

Never let actors or actresses change their method of make-up during a picture that has been started. They must, absolutely wait until the next picture to make any change in their style of making-up. One actress had a habit of appearing one day with her eyes encircled with a lovely emerald green shade and then the next day deciding to try sky-blue instead. She caused considerable trouble before she was convinced of her error.

Another myth that numerous actors entertain is the yellow grease-paint theory. Nobody can explain why a performer should make-up in chinese yellow. There is absolutely no photographic theory to account for it or its use. Let the actor make-up with grease-paint if he has a rough skin but let it be flesh-colored paint, not yellow. The objections to yellow are that it is non-actinic and if the actor happens to step out of the rays of the arcs for a moment or if he is shaded from the direct force of the light by another actor his face photographs BLACK instantly.

Yellow may be used under heavy or double chins to cause them to appear to recede or be less pronounced, or red may be used for this purpose. Yellow and red are also useful in causing eyes to appear more deep-set than they really are. For the actor who has so called "pop" eyes a shading of red around the eyes will often overcome the defect, but it must not be used as a regular shade to cover the face.

On the other hand do not allow actors to come before the camera snow-white or powdered with too light a powder. Some actresses think that the lighter they can make themselves the more youthful they appear whereas they only succeed in making themselves look like billiard balls. A good natural flesh tint with a powdering over of flesh tinted powder to kill the gloss of grease paint cannot be improved upon. This powdering should be renewed at intervals, especially if the weather is warm and perspiration causes the powder to disappear.

Hands should be given the same care in make-up that is accorded the face. Too often hands are neglected.

Wigs must be carefully adjusted and a wig that would pass on the speaking stage may not be nearly perfect enough to deceive the camera.

When assigned a part, many actors allow their beards, mustaches or hair to grow to fit the part. This, of course, requires notice some time in advance but is often done.

In designing sets or interiors for the studio, the cameraman's opinion is frequently asked. It is a good rule to try to keep the background tones several shades darker than the face of the actor for the sake of contrast. If the walls were very light the faces would appear darker than natural or sink into the background giving a flat lifeless picture.

Wall paper is frequently deceptive. A design with a heavy lavender flower may look fairly dark but will photograph almost pure white. This applies to anything with much blue or violet in it. Red and yellow will photograph somewhat darker than they appear to the eye, but are not so deceptive as the blue tones because of the orthochromatic qualities of the film.

Sets should be built two-sided whenever possible to allow the cameraman to set lamps along the open sides. If the director needs a three-sided set, places such as archways, doors, or windows should be designed through which light may be thrown. Never let the designer or stage manager tell you that you can get your light from overhead. This will not produce a good result excepting possibly in the case of prison-cells, artists' studio sets, or caverns, and such effects.

Woodwork must be dull finished. A high polish looks well to the eye but will reflect every lamp in the place and give a thousand high lights to confuse the eye and detract from the acting. If the stage painter says he cannot produce a dull luster on wood, tell him to either rub it down with paint-remover, or daub it heavily with putty. This will kill most of the gloss. Experienced stage-managers, however, will not present this abomination to the cameraman. They will finish all woodwork in flat water color or stain which photographs well.

Floors are covered either by rugs or compo-board. If the latter, the cameraman should watch closely that he does not "shoot" past the front edge as it is usually left rough and unpainted at the side near the camera.

## Chapter XXII

# RELATIONSHIP OF THE CAMERAMAN TO OTHER WORKERS

MANY times directors or scenario writers ask for absolutely impossible effects. The director expects the cameraman to know his business. He does not wish to argue with him whether or not a thing can be done. He states what he wants and says, "Can we do it?" If the cameraman is not sure let him reply. "Let me think it over an hour and I will tell you." Invariably this is satisfactory to a director but at the end of the stated time, the cameraman must say "Yes," or "No." There must be no "Maybe" or "Well, let's try it." The director wants to know whether it is a sure thing and whether it will justify his spending perhaps thousands of the company's dollars on an effect. He will not excuse any failure if the cameraman says the thing can be done. On the other hand, the cameraman can, if he considers the effect impossible, say so and usually the matter will be dropped and another idea substituted.

The director should never attempt to hurry a cameraman in focusing or getting his camera set up. If he does, it is the cameraman's duty to remonstrate and the quicker a director is told and impressed with the fact that the cameraman is not going to "shoot" until he is ready, the sooner peace and friendship will reign.

On the other hand the cameraman should not waste time or be outdoors smoking a cigarette while the director is rehearsing a scene and then, when called, come in and want to know what it is all about. The cameraman's place is back of his camera from the time the morning's work begins until lunch time and the same in the afternoon. That is why he draws a good salary. If he leaves the stage or location for any purpose let him first tell the director and state the length of time he will be away.

With the electrician—Oh—I beg you—make friends with the electrician. He is your best friend or your worst enemy. Bring him a cigar or a pack of cigarettes several times a week

*(Courtesy of Fox Film Corporation)*

THE CAMERAMAN'S PATH IS NOT A ROSE-STREWN ONE.

*(Courtesy of the Fox Film Corporation)*

PHOTOGRAPHER AND DIRECTOR MUST WORK IN UNISON.

if this will help your standing with him. If he likes you he will push the good lights into your set and see that your carbons are nicely trimmed. He, also, will get to know your methods of working and can push a heavy bank of lights just where you want it without your even telling him.

If he has it "in for you" you can holler for lights an hour and he will remain peacefully out of sight behind some barricade or other and you can rave all you please. Or fuses will mysteriously "blow" in the middle of a scene or the lights will all be working in somebody else's set—"leastwise—all the good ones" and you will, generally, feel that the world is a tough place in which to live. And the happy part of it all is that these knights of the "juice" are usually happy-go-lucky, easy-to-get-along-with fellows who are easy to cultivate. Once your friends they will remain so and do anything for you. Just treat them like human beings and exhibit some good nature. They will appreciate it.

The same applies in a lesser degree to "props," the man who takes care of the furniture and accessories used in the sets—but his particular associate in art is the director. Still, he is very useful to the cameraman when a platform is needed or a mirror is wanted to throw a reflection into some dark corner.

The stage-carpenters are usually quiet men who go about their business slowly and methodically. They are paid by the day. The cameraman will have very little to do with them but should be gracious and polite in any dealings he may have with them. They are under the direction of the stage-manager. If anything does not suit you in the construction of the set, you should talk to the stage-manager and he will direct his carpenters accordingly.

And now the STARS. Who, oh who, can tell anything about stars? Their temperament, their whims, their eccentricities! The best way for the cameraman to conduct himself is to let those personages understand, at the very start, that he is as important to the picture as they. The opportunity to do this may not come at once but, feel assured, it will arrive. Anything said must be in a gentle voice without trace of anger but just as firm as you can make it.

Stars frequently are "peevish." They will come in about ten or eleven some morning with a headache—growl at everybody—and want to hurry through the day's work and get away. The more they are humored the more overbearing they become. So long as no remarks are made direct to the cameraman on such a day he had best keep his peace as the atmosphere in the studio is usually heavily charged on that day. But any suggestion to him that—"He get a move on," or "Step on the gas," must be retorted to mildly by "Leave that part to me," or "We will do the work carefully and right, or not at all." A few remarks like this are all that is necessary to show the cameraman has a "backbone."

If the star comes along with a nickname for the cameraman it is very probably meant as a sign of his or her liking for him. However, if the nickname appears to be the result of spite or a dislike the cameraman should think up a suitable nickname for the star and apply it vigorously. A certain cameraman did not agree with his star on certain points of make-up and the star began by calling him by the name of "useless." It apparently riled the cameraman and he always replied to the hated epithet by referring to the star as "Old fathead." A few applications of this resulted in neither of the names ever being used again. Its funny but true, studios are peculiar workshops.

The cameraman will, if he is cheerful, usually get along alright with the most temperamental star. Let him just laugh or smile a little and attend to his business with a good word for everybody and never a knock for anyone. Let him object strenuously when things don't suit him or his camera, but do so in a quiet and gentlemanly manner and he will have no trouble.

"Extra" people are actors and actresses who are engaged to appear in only a few scenes. They are not on the studio payroll but are engaged by the day or half-day to appear in a scene calling for a crowd. This may be a mob scene, a dance, a cabaret, a camp of soldiers, etc. They are sometimes called "supers." It will be well, when a crowd of "extras" is about for the cameraman to keep a close watch on his equipment. Film boxes should always be locked and the lenses kept under lock and key also. I have even seen the lens on the still-camera stolen on a day when about five hundred "extras" were being used. On the same day they got away with several large silver platters, about six dozen knives and forks, and a number of costumes. Many professional pickpockets and petty-thieves mingle with these "extra" crowds just for what they term "the pickings." Therefore, keep everything not absolutely needed, in your dark room and keep it locked securely when "extras" are about. Carefully watch everything you must have on the stage.

There will also be found in every crowd of "extras" girls and women who will frequently try to ingratiate themselves with the cameraman or whoever will not repel their advances. It is best for the cameraman, as a matter of ethics, not to mingle with extra-people any more than is absolutely necessary. Some there are among them who are struggling to work their way into the studio, but the majority have other objects or no object at all, except to get a few dollars and a square meal. (The studio usually furnishes them with a free noon-day meal.)

With the manager—be businesslike. If he calls you into his office on any matter of complaint—state your side of the case quickly and pointedly. That is what he expects. Do not show any inferiority of manner or fear of anyone. The manager is usually the easiest and most considerate person about the studio with whom to get along. He is also a very busy man and the cameraman does not, as a rule, see much of him.

Your conduct to your fellow-workers is just as important to your advancement in your profession as a thorough mastery of your handicraft.

Do you ever assume a detached attitude of mind and ask yourself why you are not earning as large a salary as some other man whom you feel is not nearly as well equipped in professional knowledge as you? Do you feel that you have some handicap that you cannot define and yet which you know impedes your progress to a better position and a better standing with your fellows?

Have you had the bitter sensation of having some one whom you felt below you in the scale of experience, step ahead of you into a position that you felt should have been yours?

Most of us have, and most of us have accused our employers of unfairness, or our rivals with duplicity or made any old excuse that salved our conscience and permitted us to place the blame anywhere but where it belonged, that is, on our own shoulders.

Let it be granted that many times there have been unfair promotions and raises in salary for the other man, but before we begin any bitter recriminations and hasty bewailings of the boneheadedness and unfairness of employers, let us go to open session with our own conduct and try to ferret out the attitude and frame of mind of the employer and of our rival.

We are all prone to view the world too much from a selfish viewpoint and to accord too little respect and consideration to the viewpoint of others. We like to magnify our little troubles and tribulations and, no doubt, they are supremely important to us. Does that justify our thrusting their burden upon others and not taking into account the complications which vex them perhaps more than we are vexed?

Very, very few employers want to discharge an employee or to reduce his salary if he is giving satisfactory return for the sum he receives. If you are discharged, demoted or lose your place in line for promotion, the chances are ten to one that the fault is yours and not your employer's or your rival's. When the reason is a financial or business one, the employer is, as a rule, ready to explain the situation to the employee. Naturally in such a case no odium is attached to a let-out for reasons over which an employer has no control.

On the other, a discharged employee is often told that he is being let out on account of a reduction in the working force, because of some deficiency which is inherent to the employee, and yet which the employer has not the heart or courage to reveal to him. One cannot imagine a more embarrassing situation than that of telling an employee that he is incompetent, or undependable, or dishonest, or careless, or whatever the case may be.

It is true that there is hardly any other profession in which there is more professional jealousy and distrust than in cinematography. Many enforced hours of waiting occasioned by too few studio managers and directors and by the lack of schedule which prevails in most studios, seem to breed an incessant turmoil of gossip or recrimination or malicious scandal, causing enmities, ill-feeling, partisanships. Let us all broaden our radius and put a bridle on idle and malicious gossip. Every unkind or thoughtless word we utter, wounds and rankles and breeds others which, like boomerangs, scarify our own reputations. Our environment is a mirror which reflects our acts and thoughts.

A man's earnings are limited only by his own limitations. Are you working to broaden your scope or are you whining that others hold you back?

Cinematography is a profession that far out-classes portrait

(*Courtesy of the Universal Film Company*)

"SHOOTING" FIRE

photography in the exacting knowledge and artistic training required for its pursuit. Yet where are the Pirie MacDonalds, the Arnold Genthes, Bangs, Kasebiers, Johnstones, Hoyts, Saronys, Du Ponts, Marceaus, Reutlingers, Curtises, Bradys, Hartmans, Gillies and hundreds of other names that grace the roll of honor in portrait and pictorial photography?

An art is the sum of individual exponents. Are you adding to or detracting from the dignity of the art of cinematography? Be even more specific in your self-examination. Aside from your technical qualifications, are you a man whose conduct is entitled to respect and consideration?

Personality is a factor, a vital part of your profession. It cannot be detached from it. Do you co-operate intelligently with your director? Do you work for your salary alone? Do you study the scenario carefully? Do you try to comprehend the director's ideas and endeavor to assist him with tactful suggestions? Or, do you scorn reading the scenario and distract the busy director by asking inane questions?

Does your conduct command respect or derision? Are your opinions deferred to or are they ridiculed? Are you liked by everyone above and below your station? All of these relations depend absolutely upon your conduct. If nature has not endowed you as bountifully with pleasant attributes as some of your brothers, all the more reason that you should strive to compete with them.

Boys, none of us can more than faintly realize the far-reaching effects of the force which we are wielding. The phantom forms that daily influence and mold the thoughts and fancies of millions of people are recorded by us. One cannot over-estimate the consequence of our most thoughtless act.

To you as much as to the director belongs the task of interpretation of the author's idea. You can add inspiration and strength. You can increase its beauty, subtly render in light and shade the nuances of expression, show contrast and antithesis, correlate, delineate.

When your work reveals more than mere mechanical reproduction, when it shows both thought and imagination you have ceased to be an artisan. You are an artist.

An artist is not a man with a flowing tie and baggy trousers, nor a long-haired genius in frayed pants, although quite a lot of us seem to have that impression, if appearance is any criterion.

Carelessness in dress, action or speech betray the same characteristic in work and in technique. It is a moth-eaten idea that the artist and genius affect eccentricities of dress and manner. It is true that many brilliant men are afflicted with human weakness but it is true also that their brilliancy might have been greater if their weakness were fewer and that their greatness is not because of, but in spite of lapses of conduct. You cannot prove genius or artistic ability by imitating the bad points of brilliant men. Mimicry is the artifice of the ape; originality and self-respect the attributes of real manhood.

Dressing neatly, brushing your teeth and wearing decent footgear will not make a sissy of you and you are a lot more prepossessing and a great deal more apt to command respect and a good salary than a man with ability disguised in a shabby suit and down-at-the-heel shoes.

Your mental habits are harder to overcome than your physical ones; the mote that is in your eye is ever the hardest to perceive. The braggart, the liar, the egotist, the pessimist, are all loose and fluent talkers, and the enchantment of their own chin music drowns the groans of their unwilling and unconvinced audiences. You know them all, the braggart and liar who says, "When I was in India taking the Durbar for Kinemacolor," who wouldn't know an East India native from an American Indian, if he saw them side by side, and who never saw a motion-picture camera before he came from Coshocton, Ohio, sixteen months ago. The egotist, "Why, I'm the guy that put him in the business. I taught him everything he knows. I made-I-I-I-." And the fellow who blames everybody and everything but himself. He says, "If the lens in my camera was any good, and if the camera didn't buckle and throw a streak of static everytime I turn the handle, and if the developer hadn't ruined my stuff in the dark room, and if they hadn't cut out all the good stuff in the cutting room, it would have been a good picture."

The photographer himself is the only reason for terms of equality with director and star. There have been photographers who have risen from photography to directorship, to managership, even to ownership of companies.

"Hitch your wagon to a star" and plug. Search yourself for your handicaps and eliminate them. Make up your mind that nothing but your own actions and their consequences can hinder you. No one can advance you except yourself. Associate with successful men, ferret out the reasons for their success. If you can honestly and honorably employ their methods, do so; if not, reject them and seek others. Have confidence in your ability. If you have no confidence in yourself, can you expect others to have confidence in you? "Faint heart" never won anything worth having.

And last, but not least, don't forget that you can't preserve your faculties in alcohol.

## CHAPTER XXIII

# APPLYING FOR A POSITION

WHEN applying for a position the proper person to see, if you are not previously acquainted in the studio, is the Studio Manager.

You should request an interview and when you see him, introduce yourself and state that you wish a position as cameraman in that studio, if there is an opening.

The manager will say if there is an opening, but if he says there is not, it is useless to insist on an immediate trial of your ability.

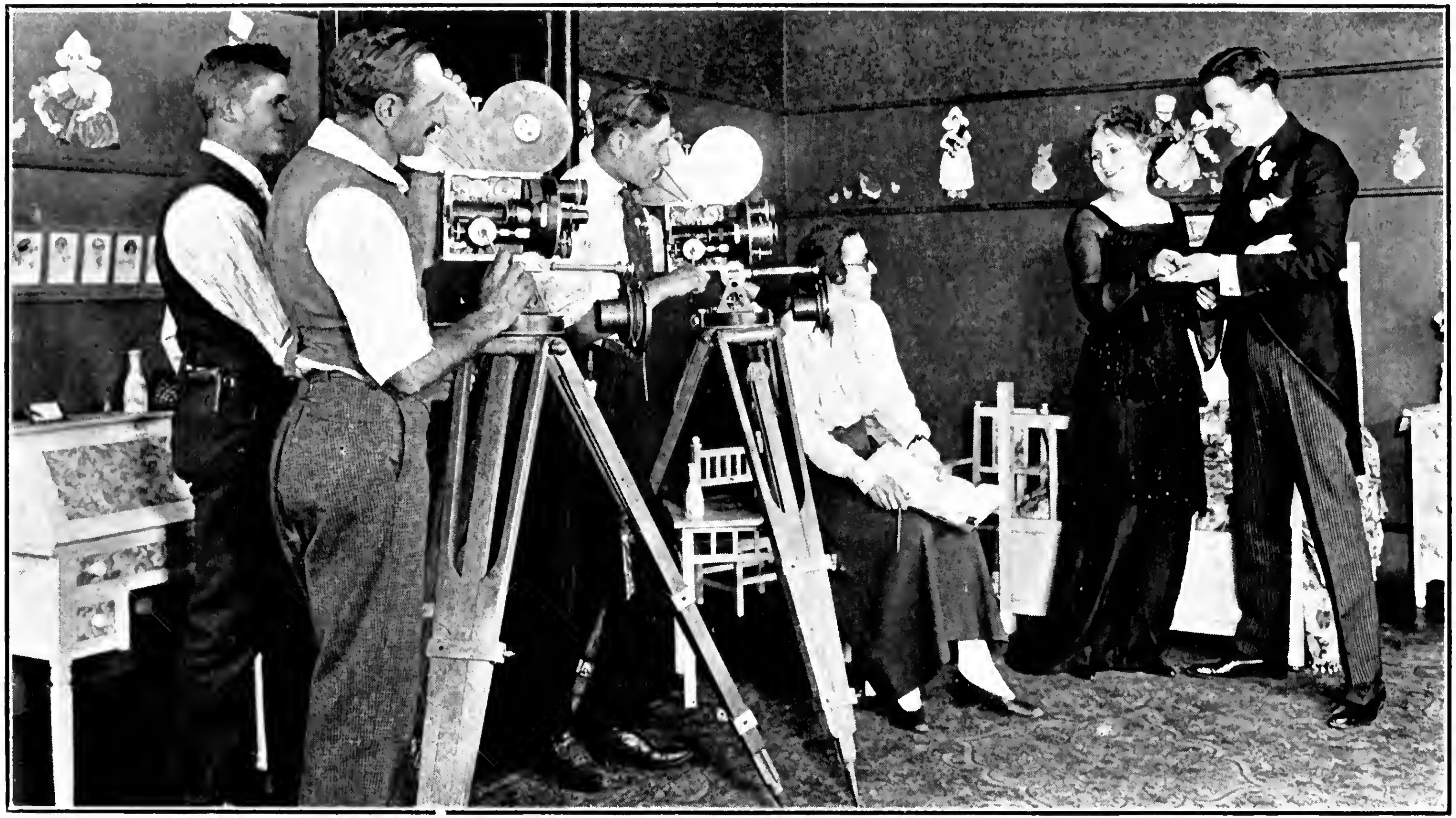
You should, however, request him to keep you in mind and leave with him your card containing your address and telephone number—that number is important as studio managers use the 'phone frequently. If you possess a camera, add the name of its make to your card.

An opening may present itself in that studio in a day or it may be a month or more before they will require another cameraman. Sooner or later they will want men and then, if your card has been filed, they will, very likely call you on the 'phone.

We will assume, however, that the manager does require a cameraman when you present yourself for an interview. He will ask you what salary you expect and, if you value your chances of a position in that place do not make too cheap a figure. A manager will appraise your worth at exactly what you appraise yourself. In large, well-established studios a salary of $100 a week will not startle the manager out of a single wink. In fact, if you ask for less he is very likely to set you down in his mind as a "crank-turner" or an amateur.

If he states that he wants you to photograph some celebrity or well-known star—do not hesitate to ask $150. You will get it if they want you.

At these figures, of course, you will be expected to furnish your own camera and complete equipment for taking the films. However, you will not be required to furnish rewinders or dark room fixtures, as these are part of the studio paraphernalia



*(Courtesy of the Universal Film Company)*

THE CINEMATOGRAPHER MUST HAVE HIS CAMERA LOADED AND READY TO SHOOT WHEN THE SCENE IS REHEARSED.

Also, most studios will keep your equipment in repair as they have well-equipped machine shops and expert machinists.

Of course, experience counts for a lot in securing a position. The first job is always the hardest to get. After you have made one good picture the rest is easy. You should not say that you have had no experience whatever as that would be fatal. It is better to say that you have been making film for yourself or free lancing considerably rather than admit you have not worked in a studio before. Of course it is advisable to state that you are a graduate of a school of photography and to show your diploma if you have it with you.

Unless you have already practiced with your camera enough to give you confidence to handle any situation that might arise in studio work, it is strongly advised that you first obtain a position as an assistant cameraman so that you can learn the ropes and adjust yourself to the customs and practices of studio work. If you have ability and perseverance you will soon get a chance to be promoted to cameraman with a substantial raise in salary. This salary will possibly not be as much as if you had attempted a cameraman's job, but you will be in a much more comfortable position of having demonstrated your ability as you went along. As soon as you have made a successful picture as a full-fledged cameraman you can again get a raise in salary—if not in the same studio, in another. One of the peculiarities of the film business is that it is generally easier to get an increase in salary by changing a position than to try to get the increase you are entitled to in the place where you are working.

You will, perhaps, be engaged on trial—services to terminate without notice if desired on either side. It is then up to you to show them that you are a man they cannot be without. If the foregoing instructions are carefully followed you can do this and establish yourself as a fixture in that studio as long as they make pictures and you wish to stay.

When going to seek a position it is advisable to wear your best clothes. There are a number of itinerant crank-turners running from pillar to post and never remaining anywhere and they usually exhibit their shiftlessness in their appearance. You do not want to be considered one of these.

Lastly, be considerate to your other cameramen. Do not act as if you knew it all just because you may have had a college education in cinematography, while they have gone through the long school of experience. You may have learned as much in a few weeks as they have gained in five years, but they are entitled to your consideration and help, if needed. A man may not know what the focal length of a lens is and yet may get good results. Some day he may have a puzzling effect to work out and may come to you for the explanation because you have had theoretical training as well as experience and practice—an ideal combination. Only a boor would then strut and throw out his chest and proclaim himself the great-know-it-all.

If you wish to impart some of your precious knowledge, do so with gentleness and modesty. You will make friends among your colleagues and they will respect and admire you.

Many operators have purchased their own motion picture cameras and have added materially to their income by filming local events for exhibition in the theatres of their home town. All of the topical or news weeklies are ready to purchase negative films of subjects of national interest and, while we do not all live in localities where pictures of such events may be obtained, except at very long intervals, yet many ingenious cameramen have discovered common things in their own territory which, when carefully taken and titled proved of general interest and salable to some of the big producing concerns.

Beautiful scenery and places of historic interest are in greater demand than ever before. The European war cut down the supply of available foreign scenic stuff and awakened an interest in the American public to the beauties of its own country. "See America First" is a slogan that should stir a thrill of real patriotism in the breast of every American citizen, and the motion picture is pre-eminently the medium of showing to the great masses of our people, who, for one reason or another, are not able to travel, the almost unknown grandeur of our own United States. Even those people who have had the good fortune to see the wonders of America enjoy the many memories recalled to them by a picture of their past travels.

Motion picture cameras are costly pieces of apparatus, it is true. The operator who wishes to begin modestly and is willing to start with a camera that, although a long way from a professional studio camera, is still capable of doing remarkably good work, can purchase one of those amateur instruments for less than a hundred dollars.

It is not necessary that the owner of a camera should develop and print pictures, although, doubtless, many of the ingeniously and mechanically inclined among you would be highly interested in doing your own work. If you can take and finish pictures with an ordinary camera, you can do the same with a motion camera.

There is a large and ever broadening field for local talent that need not in any way conflict with that of the strictly professional studio cameraman.

The enormous development of the motion picture industry has aroused the interest of millions of people and there are thousands of subjects of purely local or sectional interest which, while they are entirely outside the range of work of the big studio or factory, yet would be a profitable employment for the man who has the preliminary training that the motion picture operator must have acquired.

If your town has an event such as a celebration, a cornerstone laying, a football or baseball game, anything that brings out masses of people to see and hear men of great local importance, arrange to take a picture and let the local theatre use it for a stated sum, or, better yet, in certain instances, play it for a certain percentage of the box office receipts. Get as many of the local people in the picture as possible; most of them will come to see how they look on the screen.

Some camera owners have been very successful in making arrangements with local papers to conduct a popularity contest, after which the winners were used in staging a little play in local surroundings. The interest aroused by the advertising will bring out a large crowd to see the picture on the screen, and a local theatre can well afford to charge a small additional entrance fee and give you a good percentage of the box office receipts for the privilege of running it. Often the local theatre and local paper can be induced to work in conjunction on this kind of contest stimulating interest by throwing side pictures of the contestants and the progress of the voting upon the screen.

Another source of revenue from a picture of this kind is that of advertising various merchants and industries, by using them for backgrounds in the story and charging a reasonable price for this publicity.

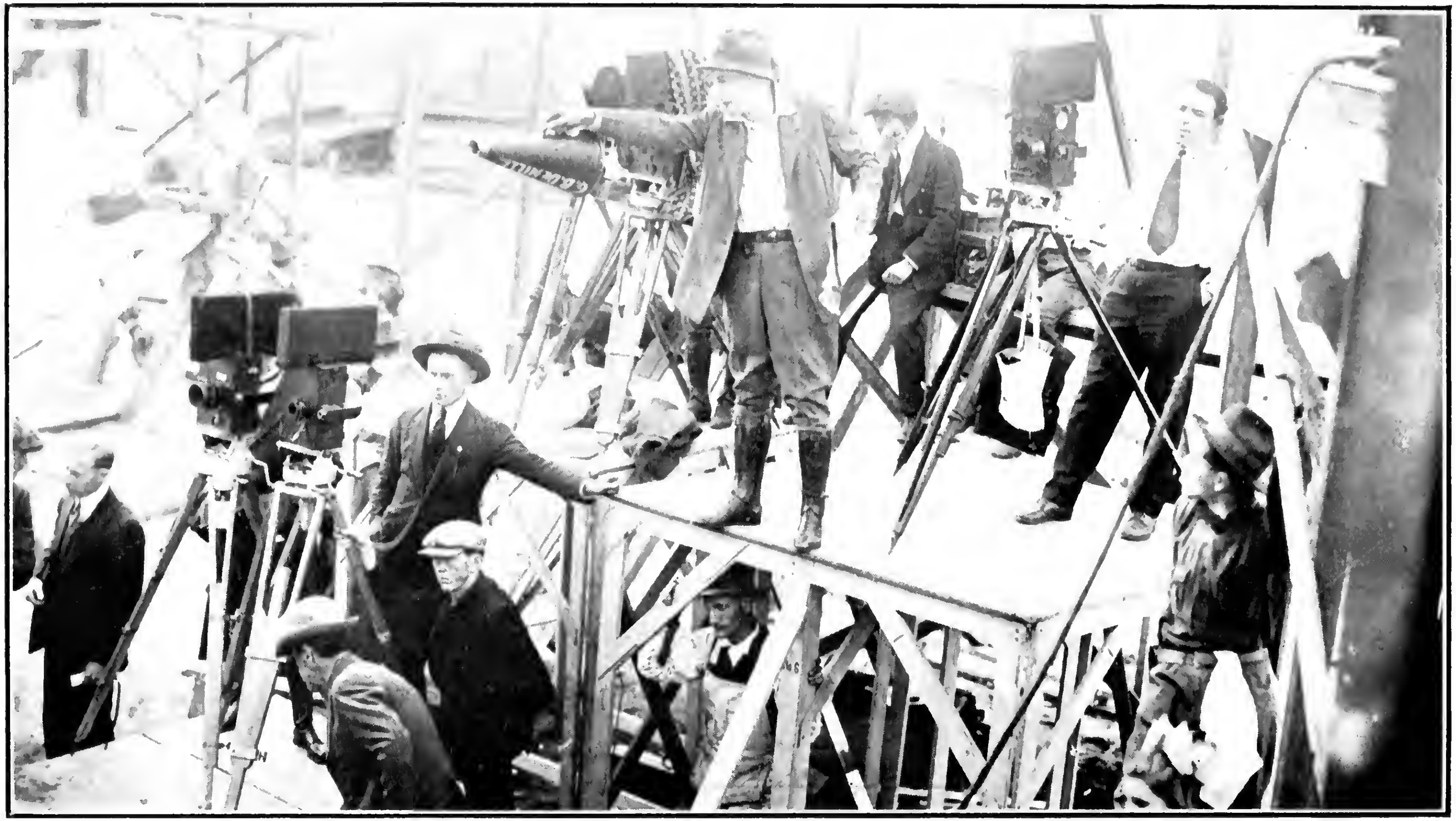
For work of this kind it is, of course, almost imperative that you use a camera of professional grade.

There are many manufacturers who would like to have motion pictures made of their factory processes, or of the workings of their products. The Ford and Studebaker automobile factories have had motion pictures made of the manufacture of their cars showing all the details of manufacture from the raw ore to the finished car. The Heinz Company has had pictures made showing the sanitary methods of making and packing preserves and the final consumption of the goods by the consumer. Many industrial processes of general interest have been regularly released by the big manufacturers of motion pictures, such as big gun forging and machining and testing; the manufacture of fountain pens; safety devices used by large corporations for protection of their workmen; the manufacture of salt, borax, soap and dozens of other staple articles; the construction of dams, spillways, power plants, viaducts, canals, bridges, etc.

There are dozens of commercial studios where negative developing and printing are done at reasonable rates. Or the ambitious amateur may construct much of his own apparatus. He can fix his camera so that he can use it as a printing machine, or he can make a printer from an old projection head. The tanks, racks, drying drums or frames can all be made at home by anyone who is handy with carpenter tools. I know of two or three experienced operators who are good mechanics, who even made their own cameras. These men, of course, were exceptions. While I would not as a rule advise everyone to try to make his own camera, I don't see why any operator who is a good mechanic and who knows photography should not derive a lot of satisfaction and fun from constructing his first camera.

An old projection head is generally too much worn and much too heavy to use for the mechanism of a camera. Beside the weight and difficulty of making over and changing the shutter, etc., the Maltese cross of Geneva movement is not suitable for the production of negatives.

In making industrial films, bear in mind that they must be of general interest unless they are being made to show only to parties interested in that particular industry. Show the interesting points, the magnitude of the industry, its great stocks of raw material, the various processes of manufacture and, most important of all, the proper use and application of the products. Get all the action possible. Don't show one thing or scene for



(*Courtesy of Famous Players-Lasky Company*)

CECIL B. DE MILLE DIRECTING A SCENE WITH FOUR PATHÉ PROFESSIONAL CAMERAS AND A BELL AND HOWELL TRAINED ON THE SET.

more than fifteen or twenty feet—ten feet is sometimes enough. Do not show the same process more than once, unless from a different viewpoint to explain it more clearly, and avoid monotonous repetitions. Don't let the manufacturer mislead you as to what is interesting. His business can never be as interesting to another as to himself.

I know two young fellows who have hobbies. One is interested in small animals, the other in insects—one lives in California and the other in a small town in New York State. Each of them has fitted a small studio for himself. Both are turning out negatives on the subjects embraced by their hobbies and selling them to big companies to be used to fill out split reels or for educational subjects.

## CHAPTER XXIV

# BIBLIOGRAPHY

ONE of the hardest problems that confronts the student of cinematography is how to find out the things that he wants to know. This book was compiled to answer most of the questions that puzzle the beginner and more advanced workers as well. Yet no one book can hope to cover all subjects and enter minutely into all of the ramifications of all the diverse branches of work embraced in the art and science of cinematography. In the first place, as cinematography is based on photography it would be superfluous to try to cover that subject before treating the main subject.

On the subject of still photography there are already printed and for sale a multitude of books which cover the subject more adequately and thoroughly than could be attempted in a text of this kind and the many still photographers who will purchase this course would not wish to pay for the additional matter with which they are already familiar. Those who have not already acquired a foundation training in still photography are advised to secure text books on the subject and study them before attempting to go deeply in the art of motion picture making.

For those who wish to consult literature on photographic and motion picture topics the following list of books has been prepared. There are many, many books on photography which are very good but which are not included in this list. This list has been compiled to help the earnest student of cinematography and each book listed is valuable in something which has a bearing on motion picture photography, although only those books listed under cinematography are devoted exclusively to that subject.

On account of the interference of the war with book publishing many of the books listed are now out of print and, too, in some cases, the price has been advanced. Copies of out of print books may, however, be consulted at libraries and stray copies of others may be picked up from photographic supply houses that were well stocked before the war.

## HANDBOOKS ON ELEMENTARY PHOTOGRAPHY

Books under this heading give the primary lessons in still photography. No one should attempt motion picture photography without having first mastered the principles of still camera work, both practically and theoretically. It is not intended that the student should buy every book in the list. One or two titles that appeal to him most will be sufficient.

EXPERIMENTAL PHOTOGRAPHY by Clement J. Leaper. A beginner's experimental course in photography, giving simple explanations of why and how. 1898. (English) 99 pp. Cloth, 50 cents. Andrew J. Lloyd Co., Boston, Mass.

EARLY WORK IN PHOTOGRAPHY by W. Ethelbert Henry (English). A useful handbook, illustrated, with a chapter on lenses by H. Snowden Ward. 3d edition, 1901. Cloth, 50 cents. Andrew J. Lloyd Co., Boston, Mass.

HOW TO MAKE GOOD PICTURES. The Eastman manual for beginners, with chapters on special subjects by noted workers, illustrated. Paper, 25 cents, Cloth, $1.00. Eastman Kodak Co., Rochester, N. Y.

ELEMENTARY PHOTOGRAPHY by John A. Hodges (English). About 100 pp. 1898. Cloth, 50 cents. Andrew J. Lloyd Co., Boston, Mass.

THE RIGHT ROAD INTO PHOTOGRAPHY by Dr. J. Nicol. 1898. A simple guide for the novice, plainly written, with instructions and formulae. Paper, 83 cents. Andrew J. Lloyd Co., Boston, Mass.

PRINCIPLES OF SIMPLE PHOTOGRAPHY by F. W. Sparrow. 1902. (English) 130 pp. Illustrated. Cloth, 50 cents.

PHOTOGRAPHY FOR NOVICES by Percy Lund. 200 pp., 50 cents.

BEGINNERS' TROUBLES (Photo-Miniature, No. 114). Paper, 25 cents. Tennant & Ward, New York City.

LIBRARY OF AMATEUR PHOTOGRAPHY, 4 vols. Comprehensive. 1,620 pp. The most complete work of its kind and a valuable reference library. This work is out of print but may be found in libraries and second-hand book stores.

INSTRUCTION IN PHOTOGRAPHY by Sir De W. Abney. Eleventh Edition, illustrated. Large 12mo. Cloth, $2.50. J. B. Lippincott, Philadelphia, Pa.

THE ROMANCE OF MODERN PHOTOGRAPHY by Charles R. Gib-

son. 63 illustrations. 345 pp. 8vo. Cloth, $1.50. J. B. Lippincott, Philadelphia, Pa.

Saturday With My Camera by Stanley C. Johnson. With over 100 diagrams and plates, 8vo. Cloth, $1.50. J. B. Lippincott, Philadelphia, Pa.

Photography of Today by H. Chapman Jones, 54 illustrations and diagrams. 342 pp. Crown 8vo. Cloth, $1.50. J. B. Lippincott, Philadelphia, Pa.

Photo-Miniature Series, Tennant & Ward, New York City, 35 cents each.

The Pocket Classics of Photography. Each book covers a different subject and covers it well. Written in a manner which every one can understand from a practical standpoint. As there are nearly two hundred subjects in this series on photography and a new subject appears each month the list is too long to print here. They are carried by all photo supply houses or a complete list may be obtained from the publishers.

## ADVANCED GENERAL TEXT BOOKS

Books for more advanced workers in still photography.

Practical Pocket Book of Photography by E. Vogel, (English) 1896. Comprehensive, brief. Cloth, $1.25. Andrew J. Lloyd Co., Boston, Mass.

Photographic Instruction Text by George H. Paltridge. 1900. A practical book. The outgrowth of a class in photography at the Lewis Institute, Chicago. 230 pp. Cloth, $1.00. Andrew J. Lloyd Co., Boston, Mass

Professional Photography by C. H. Hewitt. In two volumes (English) 1904. Illustrated. Cloth, 50 cents per vol. Andrew J. Lloyd Co., Boston, Mass.

Concise Photography by E. O. Hoppe, F. R. P. S., 1912. $4.00. The mathematical principles of photography and how to apply them. An accurate system for the careful and exhaustive student. Photo-Era, Boston, Mass.

Photography for Students of Physics and Chemistry by Louis Derr, A.M., S.B. 247 pp. $2.00 1916. MacMillan Company, New York. Not so complicated as the title sounds and an excellent book for those who really want to know the scientific principles of photography.

Barnet Book of Photography containing a complete photo-

*(Courtesy of Christie Studios)*

DOING EXTERIORS IS ONE OF THE TOUGHEST JOBS BECAUSE THE CROWD IS ALWAYS CURIOUS

graphic education. Every branch of photography is gone over in a way easily understood. Many formulae for various processes. 68 cents. Bass Camera Co., Chicago, Ill.

WATKINS' MANUAL by Alfred Watkins, 140 pp. 50 cents. Burke & James, Chicago., Ill. This book gives many useful tables, formulae, illustrations of negatives and prints, which show comparative results of correct and incorrect exposure and development. It deals with all branches of photography, such as interior work, copying, enlarging, reducing, "pinhole" photography, snapshots, speed standards, lantern slides, printing intensifying.

BRITISH JOURNAL ALMANAC. Year book of Photography. Paper, 75 cents, Cloth, $1.25. Contains many valuable formulae and tables and a resumé of the photographic improvements and progress of the year. Carried by all good photo supply houses.

## REFERENCE WORKS

No earnest worker can be without some reliable works of reference in his profession. The best reference book that one can obtain is a large loose leaf note book in which are filed the formulae and notes of the worker's personal experience and the pertinent articles that can be gradually accumulated from all sources, co-workers, trade journals, direction slips from packages of films, plates, papers, catalogs. After that come the standard reference works.

THE PHOTOGRAPHER'S NOTE BOOK by F. C. Lambert. 1897. (English). 250 practical hints, formulae, etc., clipped from all sources as worth saving. 80 pp. Cloth, 50 cents. Andrew J. Lloyd Co., Boston, Mass.

PROCESSES OF PURE PHOTOGRAPHY by W. K. Burton and Andrew Pringle. A standard compilation of the principal negative and positive processes. 1889. 200 pp. Paper, $2.00. Andrew J. Lloyd Co., Boston, Mass.

THE PHOTOGRAPHIC REFERENCE BOOK by G. H. McIntosh (English). Tells "how to do" things rather than describe methods. Brief and to the point. 835 references. 336 pp. Paper, 75 cents. Andrew J. Lloyd Co., Boston, Mass.

CASSELL'S CYCLOPEDIA OF PHOTOGRAPHY, 1912. 572 pp. The most complete, up-to-date, reliable and easy reference photographic book of recent years. Cloth, $3.75. Photo Era, Boston, Mass.

THE DICTIONARY OF PHOTOGRAPHY by E. J. Wall, F.R.P.S., 600 pp. $2.50. Photo Era, Boston, Mass. Readily accessible information compiled like an encyclopedia or dictionary.

A REFERENCE BOOK OF PRACTICAL PHOTOGRAPHY by F. Dundas Todd. A collection of valuable paragraphs on chemical processes, apparatus, etc. Paper, 25 cents. Tennant & Ward, New York City.

FIGURES, FACTS AND FORMULAE OF PHOTOGRAPHY (Photo-Miniature 134). A new selection, comprising a treasury of information for amateurs, gathered from practical experience. 35 cents. Tennant & Ward, New York City.

PHOTOGRAPHER'S NOTE BOOK AND CONSTANT COMPANION by Rev. F. C. Lambert. Contains 250 practical hints, formulae, expedients, etc. 88 pp., 60 cents. Tennant & Ward, New York City.

A PHOTOGRAPHIC REFERENCE BOOK by J. McIntosh. One of the most complete and valuable collections of photographic formulae in existence. Paper, 75 cents. Tennant & Ward, New York City.

CYCLOPAEDIC PHOTOGRAPHY by E. L. Wilson. Though published many years ago, this American cyclopaedia is extremely complete on all standard processes of photography. $2.50, Tennant & Ward, New York City.

PHOTOGRAPHY OF TODAY by H. C. Jones. A simply told account of the origin, progress, and latest achievements in photography. Illustrated. 242 pp. $1.85. Tennant & Ward, New York City.

THE ADVANCE OF PHOTOGRAPHY, ITS HISTORY AND MODERN APPLICATION by A. E. Garrett. A descriptive handbook of photographpy, paying special attention to its scientific applications. $4.25. Tennant & Ward, New York City.

## OPTICAL LANTERN WORK

The old-time projection machine or "magic lantern" is still in the ring, although the motion picture projector has handed it a mighty wallop in the jaw. Many thousands of slides are still being made, and many a projection machine operator might improve both his time and his finances by learning how they are made.

The motion picture projector is also an optical lantern and a number of books listed under cinematography treat also of the use of the projection machine.

Motion Picture Handbook for Managers and Operators by F. H. Richardson. $4.40. 432 pp. Moving Picture World, 516 Fifth Avenue, New York City. The recognized standard book on the work of projection. Complete descriptions and instructions on all leading machines and projection equipment. In any projection room this carefully compiled book will save its purchase price each month. Illustrated with numerous cuts and diagrams.

The Modern Bioscope Operator. Cloth, 200 pp., 4 shillings. Ganes, Ltd., 31 Litchfield Street, London, W. C. An English book on projection machine operation.

Lantern Slides (The Photo-Miniature Series No. 9). 35 cents. Tennant & Ward, New York City.

Lantern Slide Manual by John A. Hodges, (English), 140 pp. Diagrams. Cloth, $1.00 Andrew J. Lloyd Co., Boston, Mass.

Coloring Lantern Slides (Photo-Miniature Series, No. 83). Paper, 35 cents. Tennant & Ward, New York City.

Lantern Slide Making by F. C. Lambert, a very satisfactory manual, illustrated (English), 144 pp. Cloth, 50 cents. Andrew J. Lloyd Co., Boston, Mass.

The Optical Lantern (Photo-Miniature, No. 119). Paper, 35 cents. Tennant & Ward, New York City.

The Lantern and How to Use It by C. Goodwin Norton and Judson Bonner. Full details of all varieties of projection, including the motion picture, with all kinds of illuminants and lanterns. A complete treatise on how to run a lantern exhibition. 143 pp. 60 cents. Tennant & Ward, New York City.

Practical Slide Making by G. T. Harris. Simple working instructions for every process in the making of slides. 60 cents. Tennant & Ward, New York City.

Optic Projection by Henry Philips Gage. $3.00. 1914. Comstock Publishing Co., Ithaca, N. Y.

## LIGHT AND PHOTOGRAPHIC OPTICS

It is astonishing how ignorant most photographic workers are of even the simpler principles of optics. What would you think of a mechanic who did not know what his tools were for or what they could do? The photographer's lens is his principal tool and yet how little the most of them know about the lenses they use. Diaphragm openings seem the greatest of mysteries to many.

PHOTOGRAPHIC LENSES by C. Beck and H. Andrews. Published by a firm of manufacturing opticians as an advertisement of their specialties, but containing more practical information on the choice and use of lenses than any other work at the price. 288 pp. Illustrated (English) 1902. Cloth, 75 cents. Andrew J. Lloyd Co., Boston, Mass.

PHOTOGRAPHIC LENSES. How to choose and how to use. By John A. Hodges. 1898 (English). A good elementary handbook. Cloth, $1.00. Andrew J. Lloyd Co., Boston, Mass.

THE LENS. A practical guide to the choice, use and testing of photographic lenses. The latest and most satisfactory handbook on the every day use of lenses. By Thomas Bolas and George E. Brown (English), 164 pp. Cloth, $1.25. Andrew J. Lloyd Co., Boston, Mass.

FIRST BOOK OF THE LENS, a treatise on the action and use of the photographic lens. Not elementary, despite its title, but valuable to those familiar with mathematics. By C. W. Piper. 170 pp. (English), $1.25. Tennant & Ward, New York City.

PHOTOGRAPHIC OPTICS by R. S. Coles, M.A. 1898. An advanced manual for modern workers. Cloth, $2.50. Andrew J. Lloyd Co., Boston, Mass.

CHOICE AND USE OF LENSES (Photo-Miniature Series, No. 79). Paper, 35 cents. Tennant & Ward, New York City.

PRACTICAL NOTES ON TELEPHOTOGRAPHY. A pocket book full of reliable information on its subject. (English) 1901. 25 cents. Andrew J. Lloyd Co., Boston, Mass.

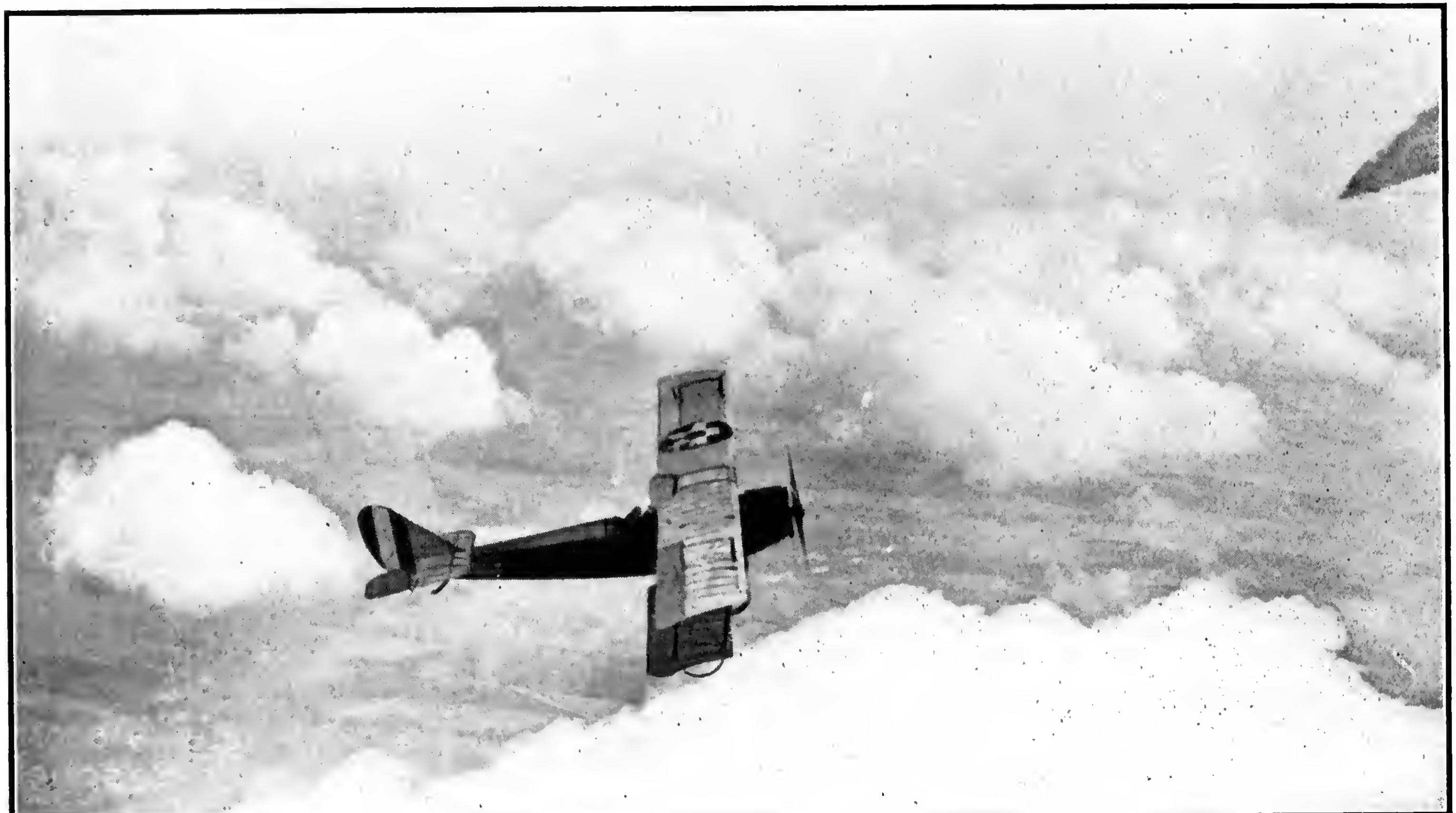
TELEPHOTO WORK by G. H. Deller. 63 pp. 50 cents. Andrew J. Lloyd Co., Boston, Mass.

PRACTICAL TELEPHOTOGRAPHY (Photo-Miniature Series, No. 90). Paper, 35 cents. Tennant & Ward, New York City.

## CHEMISTRY OF PHOTOGRAPHY

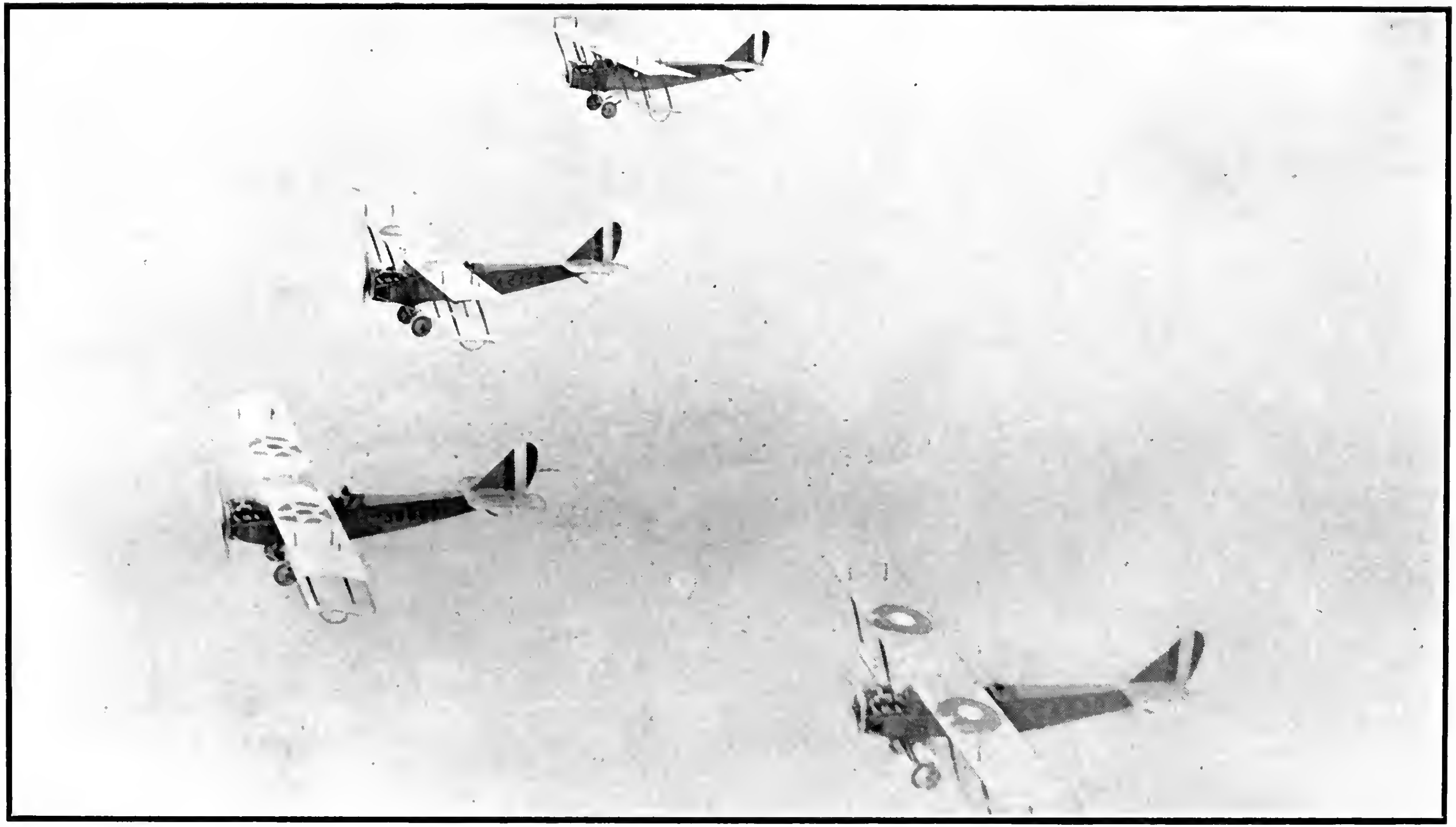
The action played by the chemicals used in photographic solutions is an interesting one, and one does not need to be a chemist to get a very good idea of why each particular chemical is used in a bath, and what effect it has on the photographic image.

CHEMISTRY FOR PHOTOGRAPHERS by C. F. Townsend. An



*(Photo by U. S. Air Service)*

FLIRTING WITH THE CLOUDS



(*Photo by U. S. Air Service*)

FLEET OF PLANES IN SQUADRON FORMATION.

excellent first handbook, not exhaustive, but simple and practical (English). 3d edition. 1902. Cloth, 50 cents. Andrew J. Lloyd Co., Boston, Mass.

THE ELEMENTARY CHEMISTRY OF PHOTOGRAPHIC CHEMICALS by C. S. Ellis (English). 1913. 113 pp. Cloth, 50 cents, Andrew J. Lloyd Co., Boston, Mass.

PHOTOGRAPHIC CHEMICALS (Photo-Miniature Series, No. 101). Paper, 35 cents. Tennant & Ward, New York City.

CHEMISTRY FOR PHOTOGRAPHERS by Wm. R. Flint. No knowledge of photography is complete without an understanding of the chemistry underlying its processes. The author has written a book for the photographer who knows no chemistry, and has described every type of reaction underlying the photographic processes in language so simple that no knowledge of chemical fundamentals beyond what is given in the book is required. The reader who masters this book will know exactly how to proceed in every photographic process to insure success. $2.00. Tennant & Ward, New York City.

PHOTOGRAPHIC CHEMISTRY (Photo-Miniature Series No. 149). Practical information about the chemistry of everyday photographic processes; the making of emulsions for plates and papers; developers and development; intensification and reduction; the making of prints; fixing; mixing chemical solutions, etc. 35 cents. Tennant & Ward, New York City.

THE CHEMISTRY OF PHOTOGRAPHY by R. Medola. A textbook embodying a series of lectures on the theory of the chemistry of photography delivered in Dublin, and chiefly valuable to students. $2.20. Tennant & Ward, New York City.

## BOOKS ON CINEMATOGRAPHY

The books under this heading comprise nearly all of the works published that are now in print which deal directly with cinematography.

PRACTICAL CINEMATOGRAPHY AND ITS APPLICATION by Frederick A. Talbot. 262 pp. 12mo. $1.10. J. B. Lippincott, Phila., Pa. This is a popular work by an English writer and while it is published for the general reader, and the moving picture fan, it holds much of interest for the cinematographer. It gives the fundamentals of motion picture production, describes the different sorts of cameras and projection apparatus used,

and gives working methods of developing of film, printing the negative, and the operation of projection. Very complete in its information and abundantly illustrated.

MOVING PICTURES: HOW THEY ARE MADE AND WORKED by Frederick A. Talbot. 270 pp. $1.50. J. B. Lippincott, Phila., Pa. On the same style as the above but containing different material about the same subjects. Not a textbook, but an interesting account of the many uses of motion pictures, and well worth reading and adding to your library.

CYCLOPAEDIA OF MOTION PICTURE WORK by David S. Hulfish, 2 vols. $4.00. American School of Correspondence, Chicago, Ill. About one-quarter devoted to motion picture photography and the remainder to projection. Also treats of picture production from the producer's and scenario writer's standpoint.

THE A. B. C. OF THE CINEMATOGRAPH by Cecil N. Hepworth. 128 pp. 50 cents. Tennant & Ward, New York City. Not an up-to-date book, but valuable as the best authority on camera movements, and interesting from an historical standpoint.

LIVING PICTURES: THEIR HISTORY, REPRODUCTION AND PRACTICAL WORKING by Henry V. Hopwood. 1899. 265 pp. and index. One of the first books published about moving pictures. In spite of its age, it contains a good deal of valuable information and is a standard work.

THE HANDBOOK OF CINEMATOGRAPHY, 200 pp. 6 shillings and 6 pence, or $1.60. Kinematograph Weekly, Tottenham St., London, W., England. Comes the nearest to being what might be called a textbook on motion picture photography in this list.

HOW TO MAKE AND OPERATE MOVING PICTURES by Bernard E. Jones. 168 pp. $1.00. Funk & Wagnalls, New York City. A very good book for the amateur cinematographer. To the beginner who wishes to learn the first steps this book is very good, but for the professional and the man already in the game, it contains little of value.

THE ART OF THE MOVING PICTURE by Vachel Lindsey. 128 pp. $1.25. MacMillan, New York, N. Y. Not properly a book on motion picture photography at all but has many interesting ideas for the cinematographer and the producer to think about.

MAKING THE MOVIES by Earnest A. Dench, 1916. $1.25. MacMillan, New York, N. Y. A "popular" science type of book for the man in the street. Interesting and instructive but not professing to teach anyone to become a cameraman.

HOW MOTION PICTURES ARE MADE by Homer Croy, 1918. Harper & Bros., New York City. 366 pp. An account of the development of the motion picture industry in America written in an entertaining fashion.

MOTION PICTURE OPERATION, STAGE ELECTRICS AND ILLUSIONS by H. C. Hortsmann and V. H. Tousley. A practical handbook and guide for theatre electricians, motion picture operators, and managers of theaters and productions. Clear, comprehensive, and accurate. $2.00. Tennant & Ward, New York City.

A B C OF MOTION PICTURES by R. E. Welsh. A practical first book on this subject. 55 cents. Tennant & Ward, New York City.

THE THEATRE OF SCIENCE by Robert Grau. $5.00 Broadway Publishing Co., New York City.

THE PHOTOPLAY: A PSYCHOLOGICAL STUDY by Hugo von Munsterberg, $1.50, D. Appleton & Co., New York City.

A CAMERA ACTRESS IN TOGOLAND by Miss M. Gehrts, J. B. Lippincott, Phila., Pa.

THE GUIDE TO KINEMATOGRAPHY by Colin N. Bennett. $1.50. E. T. Heron & Co., Ltd., Tottenham Street, London, W. This handy treatise is a successor to Bennet's well-known *Handbook of Kinematography* and is a rather more concise volume than its predecessor. A variety of subjects is considered; camera work, laboratory work and projection; each of these subjects being treated in a concise manner designed to be well understood by the novice or student.

TINTING AND TONING MOTION PICTURE FILM by Dr. Kenneth Mees, $2.50. Eastman Kodak Co., Rochester, N. Y. (Out of print.)

LIVING PICTURES by R. B. Foster, 1915. Hatton Press, Ltd., London, England.

MOTION PICTURE EDUCATION by Ernest E. Dench. $2.50. MacMillan, New York City. A treatise on methods of using the motion picture for institution and commercial use.

ADVERTISING BY MOTION PICTURES by Ernest Dench. $1.60. MacMillan, New York City. Covering the commercial end of the motion picture industry. Of interest to any camera user, with the increased popularity of the motion picture camera, this book is valuable to any one contemplating the purchase of a motion picture camera. Has many money-making devices which are open to everyone owning a cine camera. 255 pp. Illustrated.

LA CHRONOPHOTOGRAPHIE by Louis Gastine. 1899. $1.00. Gauthier Villars et Fils, 55 Quai des Grands-Augustins, Paris. A book of early cinematographic history, containing interesting illustrations of the early apparatus and results of Marey and others. Printed in French.

LA PHOTOGRAPHIE ANIMÉE by Eugene Trutat. $1.50. Publisher Gauthier Villars, Paris, 1899. A splendid edition with fine illustrations showing the early cameras and projectors used by the various well-known foreign firms. The subject of persistence of vision is explained in the thorough French style. Some present day inventors would open their eyes after reading this book, which shows that many "new and novel" mechanisms originated long ago. Printed in French.

LE CINEMATOGRAPHE: SCIENTIFIQUE ET INDUSTRIEL by Jaques Ducom. $2.00. Publishers, Cinema Revue, 118 Rue d'Assas, Paris, 1911. A pretentious volume, written in scholarly style and illustrating all the well-known foreign cine cameras and laboratory devices. A feature is the inclusion of the complete text of Demeney's "Les Origines du Cinematographe" (an important chronology of early patents). In addition to the fine illustrations Ducom's work contains practical instructions and working formulae, which combined with the historical chapters make it a most desirable reference work. Printed in French.

CONFERENCES SUR LA CINEMATOGRAPHE by E. Kress. $1.00. Publishers, Cinema Revue, Paris, 1912. Seven pamphlets. In this set of seven booklets the technique of motion picture production is studied from all angles. There is one booklet on raw film stock, and one on the early history of the art, while another treats of studio construction, lighting and proper costuming. Three numbers are devoted to a very good description of present day French cinematograph cameras, while the remaining booklet explains how all of the wonderful dissolves, visions, and tricks of the French film makers are accomplished. Printed in French.

LA TECHNIQUE CINEMATOGRAPHIQUE by Leopold Lobel. $2.50. Publishers, H. Dunod and E. Pinat, 47 Quai des Grands-Augustins, Paris, 1912. Printed in French.

MOTION PICTURE MAKING AND EXHIBITING by John B. Rathbun, $1.00. Publishers, C. C. Thompson Co., Chicago, 1914. This is not a book of working instructions and formulae but rather a description of the various processes involved in the taking, making and exhibiting of motion pictures. As such the ground is fairly well covered by the author who, it appears, is not a practical film maker. Good illustrations contribute largely to the interest of this little volume.

PICTURE PLAY PHOTOGRAPHY by H. M. Lomas, F.R.P.S., $1.50. Publisher, Gaines, Ltd. (The Bioscope) London, 1914. Lomas while quite skilled in the science and practise of ordinary photography does not provide as valuable a treatise as might be expected. The studio arrangements and lighting described are distinctly English, while in these, as is well known, we lead our otherwise superior (photographically) British cousins in the art of cinematography. There are some good points brought out by Lomas, however, and while not very comprehensive the work will doubtless prove interesting to the amateur worker.

DIE KINEMATOGRAPHIE by K. W. Wolf-Czapek, published by Union Deutsche Velagsgesellschaft, Dresden, 1908, price about 50 cents. In this booklet the late Herr Wolf-Czapek, always a keen student of the cinematographic art, explains the phenomena of persistence of vision and lays down the rudiments of cinematographic practice for the benefit of amateurs. Printed in German.

MAGIC, STAGE ILLUSIONS AND SCIENTIFIC DIVERSIONS, by Albert A. Hopkins. $2.50 Munn & Co., Inc., New York City. This book is not a cinematographic work at all, but, nevertheless, it forms an important and indispensable addition to the literature of motion photography. While the bulk of this work is devoted to elucidating the mysteries of stage-craft and the illusions of the showman, there are a number of chapters at the close of the book which deal with the making and exhibiting of motion pictures as practised in the early days of the art. A chapter on Chronophotography details and illustrates the experiments of the French pioneer, Marey, while the following chapter illustrates such historically interesting devices as Demeney's "Chronophotographe (The first Gaumont apparatus), Jenkin's "Phantoscope," Edison's "Vitascope," Lumiere's "Cinematographe" and Casler's "Mutoscope" and "Biograph." All of the early devices are illustrated from woodcuts which appeared in the *Scientific American* years back, and this is the only work at present obtainable in which these old time cameras and projectors are figured. As a matter of fact we know of no other picture of the Edison "Vitascope" than the reproduction shown in this work.

DER KINEMATOGRAPH by Dr. Carl Forch. $1.00. Publisher, A. Hartleben, Leipzig, 1913. A variety of cameras and projection devices are illustrated, ranging from the days of the Lumiere "Cinematographe" to the latest in "natural color" systems. Intermittents of many types are discussed and the geometry of Geneva movements is gone into. Printed in German.

ANIMATED PICTURES by C. Francis Jenkins, published by the author, 1898, Washington, D. C. (out of print). This volume, by one of the earliest makers of motion pictures on flexible celluloid strips, is perhaps the earliest extended treatise on cinematography. Camera work, perforating, printing and developing are dealt with, and illustrations of all the author's early devices and mechanisms are presented. Particular mention must be given the bibliography of articles and the list of patents on animated photography prior to the year 1896 which are given in this book.

## Chapter XXV

# APPENDIX

## MAKING DIRECT POSITIVES

THE problem of making positives direct in the camera without the expense of making the extra negative film where only one copy is desired has occupied the attention of many experimenters.

The following method will enable anyone familiar with the ordinary film manipulations to make good projectable positives direct in the camera.

To the camera owner who takes pictures for his own amusement, or the man who makes a single picture for his local theatre, this method will prove a great saver in cost of materials.

It is really a means of making a negative on a strip of film and then printing that negative on the same strip and destroying the original negative by a chemical process leaving the positive print.

It requires a particular style of developing apparatus, that is a drum of metal or wood painted with black Probus paint or other similar black photographic enamel which is resistant to the action of photographic chemicals. This developing drum must be smooth and tight, the skeleton type with ribs will not do, as we shall see presently.

Negative film may be used but positive film is much preferable where the strength of the light permits. Positive film gives much clearer, brighter, snappier results, i.e., negative film having a tendency to flatness and graying the high lights. As positive stock is very much slower than negative stock a much larger diaphragm opening must be used and if interiors or badly lighted exteriors are to be taken negative stock must be used. In either case the exposure must be rather full so that the image may penetrate well into the bromide of the silver film.

A very contrasty hydroquinone developer is the best to use although the usual formula for positive titles works very well. The following is a good formula:

| | |
|---|---|
| Hydroquinone | 1 oz. |
| Sulphite of soda (Dry) | 11 oz. |
| Carbonate of soda (Dry) | 7 oz |
| Potassium Bromide | 1 oz. |
| Water | 1 gallon |
| Alcohol | 1 pint |

The alcohol may be omitted but enables the developer to be used at a higher temperature thereby giving greater contrast.

Development should be slow with dim, red light so as to give a brilliant snappy negative with pure whites and deep blacks. Development must be continued until the high lights have fully penetrated to the other side of the film and the picture is plainly visible from the back. This kind of development is the chief condition of success. After development, wash for five minutes or more to thoroughly remove all traces of developer.

The development has probably caused the film to swell and lengthen and it is necessary to cinch it up close to the drum for the next operation which is that of printing the positive picture. The drum is carried to a window which admits diffused light and turned for ten to twenty seconds before the light. The white portions of the film, usually of creamy white or greenish shade, soon become grayish. This indicates sufficient exposure and the drum is carried back to the dark room and rinsed.

In this process the negative on the film is printed on the remaining silver bromide in the emulsion which has not previously been acted upon by the developer. We now see that only a tight drum can be used on which the film is tightly wound or the resulting positive would be light struck by light penetrating from the back of the film.

The tight drum has the advantage of being very economical of developer as a shallow semi-circular trough in which the drum if revolved will develop a two-hundred foot drum of film with only a gallon or two of developer.

The negative image is now destroyed or dissolved away in the following solution:

| | |
|---|---|
| Water | 1 gallon |
| Bichromate of potash | 1½ oz. |
| Nitric Acid | 3 oz. |

This bath, compared with other formulae for the same pur-

(*Courtesy of the American Film Company*)

"EXTRAS" AT WORK IN A CABARET SCENE.

pose, is very weak but as a matter of fact a very small quantity of bichromate is necessary to oxidize the silver of which the image consists. This bath is allowed to work until the negative image has been entirely dissolved away and only the creamy white of the remaining silver bromide is visible. This remaining silver bromide carries the yet undeveloped positive image from which the bichromate solution must be thoroughly washed before immersing it again in the developer to materialize the positive.

The same developer may be used in which the negative was originally developed although softer results may be obtained by using the regular metol-hydro or some other softer working developer for the second development.

After the second development the positive should be fixed for five minutes in a fixing bath containing acid hardener or, if fixed in a plain bath, hardened afterwards with formalin solution or a 5% solution of chrome alum.

The two developing solutions and the reversing solutions all have a softening effect on the film and care must be taken that the temperature does not rise sufficiently to cause the film to frill.

If trouble is experienced with softening of the film the following developer may be substituted for the one given:

| | | |
|---|---|---|
| Hydroquinone | 2 | oz. |
| Sodium sulphite (Dry) | 2½ | lbs. |
| Formaldehyde | 2 | oz. |
| Water | 1 | gallon |

This developer works very contrasty indeed and has the smarting, disagreeable odor of formaldehyde; but will absolutely prevent frilling. This is distinctly a hot weather developer and must not be used under 70° Fahrenheit.

Do not forget that a thorough development of the negative is essential to the success of this process. If this is not thoroughly done, then the lower strata of the emulsion will still contain undeveloped bromide of silver which has not been reduced to a silver negative image by the negative development and which in the following second development will be reduced in the high lights of the positive clogging them with a veil of negative which has not yet been destroyed because it must be developed before the bichromate solution can dissolve it away.

Do not attempt this process on a valuable exposure until you have made a number of test pieces successfully and are fully convinced that you can trust yourself to conduct the entire process with the same success that you would the ordinary developer and printing processes.

There are several other methods for making direct positives:

Partial reversals of negatives have been obtained by the addition of thiocarbamide and similar reagents to the developer but completely successful results are seldom, if ever, obtained. The writer has tried a reversal process similar to that used in the development of the Lumiere Autochrome plates, but has never succeeded in getting good clear high lights.

For the benefit of those who care to experiment with this interesting subject, the following details are given:

Give about twice the normal exposure required for a full timed negative and develop in the developer ordinarily used, until the high lights show through plainly on the back; after washing well for one minute the film may be brought out into the ordinary light of the room and the remaining operations carried on in this light. Immerse in either of the following solutions until the black negative image has completely disappeared:

| | |
|---|---|
| Potassium permanganate, 10% solution... | 1 dram |
| Sulphuric acid, 10% solution by volume of 1.98 acid .......................... | 5 drams |
| Water .............................. | 5 oz. |

or use this solution:

| | |
|---|---|
| Potassium bichromate ........... | 100 grains |
| Sulphuric acid .................. | 7 fluid drams |
| Water ........................ | 10 oz. |

The latter solution is probably preferable as it works faster and is not so liable to stain as the permanganate. Immerse again in the developer when the positive image will develop up. Wash and dry. It is not necessary to fix in hypo as the silver which is ordinarily dissolved out by the hypo is what forms the positive image.

Instead of the second development in developer, a sepia brown positive may be obtained by using:

Sodium sulphide, 20% solution............ 3 oz.
Water ..................................20 oz.

Formulae are given for small quantities as experiments are mostly conducted with short lengths of film of from one to four feet.

### Recovery of Silver From Spent Hypo Solutions

For the precipitation of the silver from the hypo, two capacious tanks of concrete should be constructed a good distance away from the building; for the chemical used as a precipitant, when acted upon by an acid, produces a gas, the smallest quantity of which being present in the atmosphere of the dark room, fogs sensitive emulsion just as surely as sunlight would.

The two tanks should each be of sufficient capacity to hold at least a week's run of spent hypo; the top level of the lower one being below the bottom of the upper one. Each tank should be provided with a series of cocks or outlets or an adjustable syphon, thereby the liquid can be drawn off at any desired level and a weatherproof, but easily removable cover, and, if the size of the tanks warrants, a small flight of steps for the laborer who shovels the silver sludge into barrels.

On account of the disintegrating action of the hypo solution the concrete should be protected by a heavy coat of asphalt. The upper tank has an inlet pipe from the dark room through which it receives its charge of solution and all its outlets drain into the lower tank. The lower tank in turn drains into the sewer.

The precipitating solution is liver of sulphur of the cheapest commercial grade. It comes in large chunks of the fused chemical, varying in color from light brown to dark brown, according to the purity. Chemically it is a mixture of indefinite polysulphides of sodium and potassium, and the precipitate which it forms with the silver is silver sulphide, a dirty, brownish black appearing substance. Liver of sulphur is very soluble in water but, on account of the large impervious pieces in which it comes, it takes a long time to dissolve unless broken up, and breaking it up is no pleasant job, as it has the quintuple fragrance of ancient eggs. It is a good plan, therefore, to have a stout barrel or hogshead of snug-fitting cover, in which are placed water and chemical enough to have a saturated solution constantly on hand.

Where it is not possible to have tanks on different levels, a small bronze centrifugal or rotary pump and electric motor will take care of the solution nicely. When the upper tank is two-thirds full of hypo solution and sulphuret solution, stir with a wooden paddle and pause once in a while to let the precipitate settle a little, and take a glass full of the supernatant liquid and add a little of the sulphuret solution to see if there is any further precipitation. If it produces a dark brown cloudy precipitate it is necessary to add more precipitant, but if the precipitate is only slightly cloudy or absent, the precipitation is complete and the tank should be allowed to settle until the next day, when the clear supernatant liquid may be carefully decanted into the lower tank. However careful you may be, you will find that it is impossible to remove all of the supernatant liquid without a portion of the precipitate escaping into the next tank. It is to receive and save this escaping precipitate that the lower tank was constructed. The lower tank is now allowed to settle and the clear liquid allowed to run into the sewer. This precipitation may be repeated until the accumulation of sludge in the bottom of the tank is sufficient to warrant putting it into tight barrels for shipment to the refiner.

If any acid is used in the hypo do not fail to run enough spent developer solution into the tank to make sure that all the acid is neutralized and that the solution is decidedly alkaline. If this is not done the acid will react on the liver of sulphur and foul the whole neighborhood with the abominable odor of sulphuretted hydrogen or hydrogen disulphide, which has rotten eggs backed off the boards for fragrance.

Reducing solutions and silver intensifying baths may also be run into these tanks for recovery of their silver content.

### Film Development in Hot Climates

Film may be successfully developed under tropical conditions (up to 95° F.) by means of most developers, with the addition of 10% sodium sulfate and some potassium bromide in order to prevent fog, but much better with a special developer compounded with paraminophenal hydrochloride. Although it has been recommended to develop film in the tropics by hardening the same either before or after development by the addition of a hardener such as formalin, it is only possible to secure the best results by using a developer free from such additional agents. The formula for the developer is as follows:

| | Avoirdupois |
|---|---|
| Paramidophenol hydrochloride | 360 grs. |
| Sodium sulfite (Des.) | 6 oz. |
| Sodium carbonate (E. K. Co.) | 6 oz. |
| Water to | 1 gallon |

Rinse for only one or two seconds before placing in the fixing bath, otherwise the film is apt to soften in the rinse water.

The time of development with Eastman film at 95° F. for normal contrast is one and a half minutes though the time of development may be doubled by the addition of 100 grams of sodium sulfate (crystal) per liter of developer.

At temperatures up to 75° F. the regular acid fixing bath should be used, but at temperatures up to 85° F. the following chrome alum bath is necessary:

| | Avoirdupois |
|---|---|
| Hypo | 1 lb. 12 oz. |
| Sodium sulfite (Des.) | 5½ oz. |
| Potassium chrome alum | 11 oz. |
| Acetic acid (glacial) | 160 minims |
| Water to | 1 gallon |

Dissolve the sulfite and chrome alum together and add to the hypo solution finally adding acetic acid.

At temperatures up to 95° F. the following formalin bath should be employed:

| | Avoirdupois |
|---|---|
| Hypo | 2 lbs. 2 oz. |
| Sodium sulfite (Des.) | 7 oz. |
| Formalin (formaldehyde 40%) | 17 oz. |
| Water to | 1 gallon |

First dissolve the hypo, then the sulfite, and finally add the formalin.

In order to eliminate the odor of the formalin, the bath should be enclosed in a covered tank if possible. The above baths keep well at the temperatures stated, so that the special chrome alum bath is very suitable, while in special cases such as expeditionary work, when very high temperatures may prevail, the formalin bath will give perfect results.

Still picture negatives may be successfully treated in a tray in the same way as film though so far it has not been possible to devise a method of using the Kodak film or film pack tanks at the temperatures named.

Although no difficulty is to be expected when developing gas light and bromide papers at high temperatures, the use of a stop bath of 3% acetic acid, and twice the usual amount of liquid hardener in the fixing bath is recommended.

## United States Weights and Measures

ABBREVIATIONS USED BELOW

**Ounce, oz.; pint, pt.; quart, qt.; pound, lb.; gallon, gal.; grain, gr.; gram, gm.; pennyweight, pwt.; scruple, scr.; dram, dr.**

| | |
|---|---|
| 16 oz. | 1 pt. |
| 2 pts. | 1 qt. |
| 4 qts. | 1 gal. |

16 oz. or a pint is sometimes called a fluid pound.

### *Troy Weight*

| | |
|---|---|
| 24 grs. | 1 pwt. |
| 20 pwts. | 1 oz. |
| 12 oz. | 1 lb. |

### *Apothecaries' Weight*

| | |
|---|---|
| 20 grs. | 1 scr. |
| 3 scr. | 1 dr. |
| 8 dr. | 1 oz. |
| 12 oz. | 1 lb. |

The pound, ounce and grain are the same in both Apothecaries' and Troy weights.

### *Avoirdupois Weight*

| | |
|---|---|
| 1.77 gms. | 1 dr. |
| 27.34 grs. (Troy) | 1 dr. |
| 16 dr. | 1 oz. |
| 16 oz. | 1 lb. |

## Engish Weights and Measures

### *Apothecaries Weight*

| | | |
|---|---|---|
| 20 grs. | 1 scr. | 20 grs. |
| 3 scr. | 1 dr. | 60 grs. |
| 8 dr. | 1 oz. | 480 grs. |
| 12 oz. | 1 lb. | 5760 grs. |

*Fluid Measures*

| | |
|---|---|
| 60 minims | 1 fluid dr. |
| 8 dr. | 1 fluid oz. |
| 20 oz. | 1 pt. |
| 8 pts. | 1 gal. |

The above weights are usually adopted in compounding photographic formulae.

*Avoirdupois Weight*

| | |
|---|---|
| 27 11/32 gr. | 1 dr. |
| 16 dr. | 1 oz. |
| 16 oz. | 1 lb. |

Photographic chemicals are as a rule sold by avoirdupois weight.

### Handy Emergency Weights

In an emergency, coins may be used as weights, and the weights given in the following table are accurate enough for all ordinary purposes.

| | |
|---|---|
| Dime | 40 grs. |
| Cent | 50 grs. |
| Nickle | 80 grs. |
| ¼-Dollar | 100 grs. |
| ½-Dollar | 200 grs. |
| Dollar | 400 grs. |

By simple addition and subtraction many different weights can be made with these coins; for instance to obtain a weight of 10 grains, place a cent on one side of the scale and a dime on the other and then add enough of the chemical to balance the scale.

### Electrolytic Recovery of Silver From Waste Solutions

The main source of silver lies in the exhausted negative fixing solutions and in the hypo baths in which positive film has been fixed. These solutions are certainly worth saving, amounting to $100 or more per month in even a small-sized film laboratory. By a novel method of precipitating the silver, a plan has been formed that entirely supercedes the use of that very offensive chemical, sulphide of potassium (liver of sulphur). The precipitated silver is brought about by electro-chemical action, every grain contained in the waste hypo fixing solutions being precipitated, without either loss or offensive smell, or there are no volumes of liberated sulphuretted hydrogen emitted as is the case always when the potassium sulphide is used, which is not only offensive, but is also injurious to the health of those who have to work within its sphere of action, and causes injury to every kind of sensitive material that may be in near proximity to vessels that contain the waste solutions. Where there are large quantities of waste hypo solution use two asphalt-lined concrete or brick tanks, fitted with stop cocks at intervals from the bottom, to run off the exhausted solution after precipitation, in the same way as used for sulphide plan. If smaller quantities are used, large barrels will be just the thing. Now for the process. Obtain half a dozen sheets of zinc, any thickness will do; suspend them from the top of the tank or barrel by means of two very stout, long copper wire hooks, these hooks being held in position by as many wooden strips across the top of the tank. The bottom ends of the hooks and the sheets of zinc must be completely submerged in the old fixing solution.

If the bath is alkaline, sulphuric or acetic acid should be added until it is distinctly acid to litmus paper. The acid condition of this mixture will set up an electric current, with the result that the zinc becomes consumed, and the metallic silver is thrown down as a dark gray powder, so much so that if the liquid is left undisturbed for a week the whole of the silver will be thrown down and the liquid above will be clear. The electric action is due to the copper wires and the zinc plates in contact with the acid hypo solution.

As soon as this occurs, this exhausted liquid may be drawn off and thrown away. A good plan to adopt is to fill one tank first, then arrange this for precipitation while the second tank is being filled. Of course this will take some time. This will allow complete precipitation in one tank.

This process must be continued until there is a considerable deposit formed at the bottom before removal in the same way as employed when using sulphide. The difference between the two methods is that in one the precipitate is sulphide of silver, while in the other the precipitate is mainly metallic silver thrown down without waste.

The cost of scrap zinc is about five or six cents per pound, so that the cost eventually of precipitating one pound of silver will not be so much as would be the case with potassium sulphide, the cost of which is about 15 cents per pound.

Sixty-five and a half ounces of zinc is capable of precipitating 108 ounces of silver under exact chemical conditions, allowing for small losses during this method of electrolytic precipitating. It can be safely stated that a pound of zinc will throw down a pound of silver.

The following result has been obtained by the method described. About 10½ gallons of spent hypo was used. The dried silver precipitate amounted to fifteen ounces which sold at fifty cents an ounce. Where it is considered that this quantity has been obtained with but little labor, small cost and no offensive smell, the method should bid fair to supplant the potassium sulphide plan in every photographic establishment. No special skill is necessary; any person who possesses a small amount of common sense can attend to it, insuring as it does, the depositing of every grain of silver contained in the old fixing bath, thus giving a profitable return in cash that will aid considerably in reducing the cost of production.

### Dead or Flat Black Varnish for Blacking Inside of Cameras, Tubes, Etc.

| | |
|---|---|
| Alcohol | 8 oz. |
| Lamp black | 2 oz. |
| Shellac | 1 oz. |

Dissolve the shellac in alcohol by agitation, then add the lamp black and mix thoroughly.

### Black for Diaphragms, Shutters and Other Metallic Parts

| | |
|---|---|
| Nitric acid | 4 oz. |
| Copper wire | ¼ oz. |

Dissolve the copper wire in the nitric acid and then add slowly 1¼ oz. of water. The parts to be blackened must be thoroughly cleaned, then heated and immersed in the acid bath after which they are taken out and brushed off or until the article shows a rich blue black.

### Ink for Writing on Glass

White Ink—Mix 1 part Chinese white (water-color pigment) or barium sulphate with 3 or 4 parts of sodium silicate solution (water glass). The sodium silicate solution should have the consistency of glycerin.

Black Ink—Mix 1 part liquid Chinese ink (or Higgin's Eternal

Ink, or some similar carbon ink) with 2 parts sodium silicate solution.

Apply with an ordinary steel pen. The ink will dry in fifteen minutes and will withstand water. It may be readily removed by scraping with a knife.

### Dead Black for Wood

| | | |
|---|---|---|
| Borax | 30 grs. | 8 gms |
| Glycerine | 30 minims | 8 c.c.s. |
| Shellac | 60 grs. | 16 gms. |
| Water | 8 oz. | 1000 c.c.s. |

Boil till dissolved and add

| | | |
|---|---|---|
| Nigrosine, W.S. | 60 grs. | 16 gms. |

Or paint the wood first with

| | | |
|---|---|---|
| Cupric chloride | 75 grs. | 75 gms. |
| Potassium bichromate | 75 grs. | 75 gms. |
| Water | 2¼ ozs. | 1000 c.c.s. |

and as soon as the surface dries apply

| | | |
|---|---|---|
| Aniline hydrochlorate | 150 grs. | 150 gms. |
| Water | 2¼ ozs. | 1000 c.c.s. |

and wipe off any yellow powder that forms. Repeat the process till black enough, and then rub over with boiled linseed oil.

### Waterproofing Solution for Wood

| | | |
|---|---|---|
| Asphalt | 4 ozs. | 400 gms. |
| Pure rubber | 30 grs. | 6 gms. |
| Mineral naphtha | 10 ozs. | 1000 c.c.s. |

Apply with stiff brush and give three successive coats, allowing to dry between each. The vapor from this solution is very inflammable.

### Polish for Cameras, Woodwork, Etc.

| | | |
|---|---|---|
| Linseed oil | 20 ozs. | 400 c.c.s. |
| Spirits of camphor | 2 ozs. | 40 c.c.s. |
| Vinegar | 4 ozs. | 80 c.c.s. |
| Butter of antimony | 1 oz. | 20 gms. |
| Liquid ammonia | ¼ oz. | 5 c.c.s. |
| Water | ¼ oz. | 5 c.c.s. |

This mixture is applied very sparingly with a bit of old flannel, and thoroughly rubbed off with soft rags.

### Blackening Brass Work

| | | | |
|---|---|---|---|
| A. | Copper nitrate | 200 grs. | 450 gms. |
| | Water | 1 oz. | 1000 c.c.s. |
| B. | Silver nitrate | 200 grs. | 450 gms. |
| | Water | 1 oz. | 1000 c.c.s. |

Mix A and B, and place the brass work (perfectly cleaned) in the solution for a few moments, heating it on removal.

### Varnish for Brass Work

| | | |
|---|---|---|
| Celluloid | 10 grs. | 4 gms. |
| Amyl alcohol | ½ oz. | 100 c.c.s. |
| Acetone | ½ oz. | 100 c.c.s. |

Instead of this cold celluloid varnish, commercial "cold lacquer" can be used.

### To Blacken Aluminum

Clean the metal thoroughly with fine emery powder, wash well and immerse in

| | | |
|---|---|---|
| Ferrous sulphate | 1 oz. | 80 gms. |
| White arsenic | 1 oz. | 80 gms. |
| Hydrochloric acid | 12 ozs. | 1000 c.c.s. |

Dissolve and add

| | | |
|---|---|---|
| Water | 12 ozs. | 1000 c.c.s. |

When the color is deep enough dry off with fine sawdust, and lacquer.

### Silvering Mirrors (Martin's Method)

In employing the following formulae, it should be well understood that the glass plate to be silvered must be scrupulously clean.

| | | | |
|---|---|---|---|
| A. | Nitrate of silver | 175 grs. | 40 gms. |
| | Distilled water | 10 ozs. | 1000 c.c.s. |
| B. | Nitrate of ammonium | 262 grs. | 60 gms. |
| | Distilled water | 10 ozs. | 1000 c.c.s. |
| C. | Pure caustic potash | 1 oz. | 100 gms. |
| | Distilled water | 10 ozs. | 1000 c.c.s. |
| D. | Pure sugar candy | ½ oz. (Avoir.) | 100 gms. |
| | Distilled water | 5 ozs. | 1000 c.c.s. |

Dissolve and add

Tartaric acid ........ 50 grs........ 23 gms.

Boil in flask for ten minutes, and when cool add

Alcohol ............ 1 oz. ....... 200 c.c.s.

Distilled water, quantity sufficient of make up to 10 ozs. or 2000 c.c.s.

For use, take equal parts of A and B. Mix together also equal parts of C and D and mix in another measure. Then mix both these mixtures together in the silvering vessel, and suspend the mirror face downward in the solution.

### Thermometric Rules

The following rules for the rapid conversion of degrees in one system into another will be found useful:

To convert Centigrade into Fahrenheit:

Degrees centigrade times 9 divided by 5 plus 32.

Ex.—80° C. times 9 divided by 5 equals 144 plus 32 equals 176° F.

To convert Centigrade into Réaumur:

Degrees Centigrade times 4 divided by 5.

Ex.—60° C. times 4 divided by 5 equals 48° R.

To convert Fahrenheit into Centigrade:

(Degrees Fahrenheit minus 32) times 5 divided by 9.

Ex.—100° F. minus 32 equals 68 times 5 divided by 9 equals 37.8° C.

To convert Fahrenheit into Réaumur:

(Degrees Fahrenheit minus 32) divided by 9 times 4.

Ex.—95° F. minus 32 equals 63 divided by 9 times 4 equals 28° R.

To convert Réaumur into Centigrade.

Degrees Réaumur times 5 divided by 4.

Ex.—80° R. times 5 divided by 4 equals 100° C.

To convert Réaumur into Fahrenheit.

Degrees Réaumur times 9 divided by 4 plus 32.

Ex.—16° R. times 9 divided by 4 equals 36 plus 32 equals 68° F.

### Depth of Field

Depth of field is governed by angular aperture, which is a measure of the angle at the apex of the cone of light reaching the plate when focusing on an infinitely distant point of light. The diameter of the angular aperture is the diameter of the base of the cone when its height is made equal to the focal length. Depth is often calculated on effective aperture; this introduces small errors that are very generally ignored.

Let *a* equal focal length divided by diameter of angular aperture, *c* equal diameter of circle of confusion. Usually taken at 0.01 inch but for critical definition 0.005 is necessary.

*H* equals hyperfocal distance. See definition below.

Then $H$ equals $\frac{f^2}{ac}$ equals $\frac{100 f^2}{a}$ when $c$ equals 0.01 inch measuring all distances from node of admission.

If we focus on infinity, the nearest object in focus is at a equal to *H*.

If we focus on a distance equal to $H + f$, all objects are in focus from $\frac{H + f}{2}$ up to infinity. This is the maximum amount of depth possible.

If we focus on a point at a distance $u$ the distance of nearest object in focus equals $\frac{Hu}{H + u - f}$ equals $\frac{Hu}{H + d}$ and the distance of farthest object in focus equals $\frac{Hu}{H - u + f}$ equals $\frac{Hu}{H - d}$.

When $f$ is small compared with $u$ it can be disregarded, and $u$ and $d$ can be considered equal, while distances can be measured either from the node or the principal focus.

Very approximately, when we focus on a distance equal to $\frac{H}{—}$

depth extends from $\frac{H}{n + 1}$ to $\frac{H}{n - 1}$.

If an image produced with a lens of focal length $f$ and with aperture of $f$ number $a$ is enlarged $n$ times the result is equivalent, both as regards size and depth, to one produced directly with a lens of focal length *nf* and aperture *f* number *na*, that is, an aperture of the same diameter.

To produce the same depth with two different lenses the aperture *f* numbers must vary in proportion with the squares of the focal lengths.

## Eastman Negative and Positive Film Developer for Motion Pictures

Developer No. 16 is a formula worked out by the Research Laboratories of the Eastman Kodak Company and recommended by them as being most suitable for the film stock which they supply. The writer recommends that wherever the conditions will permit that separate tanks of developer be kept for positive and negative stock even though the same formula be used in each tank. A bath which has been used for positives will not produce as good results on negative stock as one which is reserved exclusively for that purpose.

### Developer No. 16

Dissolve the following chemicals in order named:

| | *Avoirdupois* | *Metric* |
|---|---|---|
| Water (8⅓ Imperial gals.) .. | 10 U. S. gals .. | 40 l. |
| Elon (metol) ............. | 180 grs. ........ | 12 grm. |
| Sodium sulphite (des.)..... | 3 lbs. 5 ozs... | 1590 grm. |
| Hydroquinone ............ | 8 ozs. ....... | 240 grm. |
| Sodium carbonate (des.).... | 1 lb. 9 ozs.... | 750 grm. |
| Potassium bromide ........ | 1 oz. 63 grs... | 36 grm. |
| Citric acid ................ | 400 grs. ...... | 28 grm. |
| Potassium metabisulphite ... | 2 ozs. ...... | 60 grm. |

When in use, temperature of developer should be maintained at 65° F. When development is complete, rinse film in two changes of water and fix in an acid fixing bath.

Although there are reasons against the use of the same developer for negatives and positives, the following is capable of yielding most satisfactory results for both, and is recommended for use where the number of developing tanks is limited.

### Metol-Hydroquinone Developer

| | | |
|---|---|---|
| Water | 180 | gals. |
| Hydroquinone | 8 | lbs. |
| Sodium sulphite (anhydrous) | 40 | lbs. |
| Sodium carbonate | 22 | lbs. |
| Potassium bromide | 1½ | lbs. |
| Potassium metabisulphite | 2 | lbs. |
| Metol | 8 | ozs. |
| Citric acid | 10 | ozs. |

The following is slower in action:

| | | |
|---|---|---|
| Water | 160 | gals. |
| Hydroquinone | 8 | lbs. |
| Sodium sulphite (anhydrous) | 25 | lbs. |
| Sodium carbonate | 25 | lbs. |
| Potassium bromide | 1 | lb. |

Care must be taken to have temperature 65° to 70° F. as hydroquinone does not work well below 65° and is too contrasty above 70°.

*Edinol—Hydro Developer for negatives only*

| | | |
|---|---|---|
| Water | 160 | gals. |
| Acetone sulphite | 6 | lbs. |
| Sodium sulphite (anhydrous) | 24 | lbs. |
| Edinol | 2½ | lbs. |
| Hydroquinone | 1½ | lbs. |
| Potassium bromide | 1 | lb. |
| Potassium carbonate | 40 | lbs. |

Note—This is an excellent developer for Negatives, Films or Plates, but not suitable for Positives.

### A Glycin Developer

Glycin is slow acting developer which keeps for a long time and yields negatives perfectly free from stain. It also makes an excellent positive developer giving a rich blue black print and when re-developed gives very pleasing sepia tones. Its keeping qualities and close grained deposit recommend it especially for those whose work is on small quantities and infrequent. When exhausted it becomes strongly fluorescent showing a bluish cast like kerosene and should then be thrown away.

Try the following formula and if you find it satisfactory you can easily calculate for larger quantities:

| | |
|---|---|
| Glycin | 2 ozs. |
| Sodium sulphite | 5 ozs. |
| Potassium carbonate | 10 ozs. |
| Water | 1 gal. |

### Metol Substitutes

Metol is the trade name of a German-made developing agent which was in extensive use in this country before the War. Genuine Metol has been practically unobtainable since the first year of the war and yet the name had become so firmly rooted that it is still used as a designation for any one of a number of developing agents of similar properties which may be substituted for it in the preparation of developing solutions.

The names of some of them are as follows: Monomet, Elon, Kodalon, Phenomet, Paramidophenol, Ardel, Wallace's "Metol," Cooptol, Rhodol, etc., any of which may be substituted for metol in any developer formula. Most of them may be substituted in equal quantities, those which require more or less so state on the sheet of directions accompanying them.

### Motion Picture Negative Developer

| | | |
|---|---|---|
| Water | 160 gal. | 1 gal. |
| Metol | 12 oz. | 1¼ dr. |
| Hydroquinone | 3 lbs. | 4¾ dr. |
| Sodium sulphite (anhydrous) | 30 lbs. | 3 oz. |
| Sodium carbonate (anhydrous) | 10 lbs. | 1 oz. |
| Potassium bromide | 8 oz. | ⅘ dr. |
| Citric acid | 1 lb. | 1½ dr. |

### Positive Developer

| | | |
|---|---|---|
| Water | 200 gal. | 1 gal. |
| Paramidophenol sulphate | 12 oz. | 1 dr. |
| Hydroquinone | 27 oz. | 2¼ dr. |
| Sodium sulphite (anhydrous) | 28 lbs. | 2¼ oz. |
| Sodium carbonate (anhydrous) | 24 lbs. | 1¾ oz. |
| Potassium bromide | 10 oz. | 22 gr. |
| Sodium hydroxide | 4 lbs. | 5⅛ dr. |

### Fixing Bath

While the ordinary plain "Hypo" of two pounds of hypo per gallon of water seems all that may be desired, yet there are times and conditions where it fails, particularly in hot weather. The following mixture (for all times) on account of its unfailing certainty even under the most trying conditions is recommended.

### Acid Hypo Fixing Bath

| | *Avoir.* | *Metric* |
|---|---|---|
| Water | 10 gals. | 40 l. |
| Hyposulphite of soda | 21 lbs. | 10 kg. |

When thoroughly dissolved, add the following hardener:

| | | |
|---|---|---|
| Water | 40 oz. | 1200 c.c. |
| Sodium sulphite (des) | 4 oz. | 120 gms. |
| Alum | 8 oz. | 240 gms. |
| Acetic acid 28% | 24 oz. | 720 c.c. |

When fixing is complete, wash thoroughly and immerse for two minutes in the following:

*Glycerine Bath*

| | *Avoir.* | *Metric* |
|---|---|---|
| Water | 10 gals. | 40 l. |
| Glycerine | 32 liq. oz. | 1 l. |

The object of the glycerine bath is to maintain flexibility in the film.

### Another Acid Fixing Bath

Mix in the order given.

| | | |
|---|---|---|
| Water | 250 | gals. |
| Hyposulphite of soda (crystals) | 400 | lbs. |
| Sodium sulphite (anhydrous) | 25 | lbs. |
| Acetic acid No. 8 (½ carboyer) | 50 | lbs. |
| Powdered alum | 1½ | lbs. |

Note—Remove "scum" before using. Where mixing facilities permit, it is better to mix the last three ingredients separately in 10 gallons of the water and decant or filter into the hypo after settling.

## INTENSIFIERS

### Silver Cyanide Intensifier

In cartoon and title work where intense contrast is wanted between black and white, an intensifier is often wanted that will give an unusual degree of intensification. Such an intensifier may be made as follows:

*Sol. A.*

| | |
|---|---|
| Bromide of Potassium.................. | 1 lb. |
| Bichloride of mercury ................ | 1 lb. |
| Water ................................ | 10 gals. |

*Sol. B.*

| | |
|---|---|
| Pure cyanide of potassium.............. | 1 lb. |
| Nitrate of silver...................... | 1 lb. |
| Water ................................ | 10 gals. |

Place the film to be intensified in Sol. A until the image has bleached clear through to the back of the film, then rinse well and transfer to Sol. B.

Note—These solutions are highly poisonous.

One immersion gives a heavy degree of intensification but if a greater degree is required the operation may be repeated.

### Intensification by Toning

A very considerable degree of intensification may be given a negative by toning it sepia in the same bath that is used for toning sepia positives. Full directions are given in the chapter on Tinting and Toning.

### Iodide of Mercury Intensifying Formula

Note—This solution is poisonous and should be labeled "POISON."

This method is more regular than bichloride of mercury and has the faculty of reducing contrasts in addition to intensifying the general image.

| | | |
|---|---|---|
| Water ........................... | 100 | gals. |
| Sulphite of soda (anhyd.)........... | 83 | lbs. |
| Iodide of mercury .................. | 8¼ | lbs. |

Submerge the frame of film in this solution and allow to remain therein until the desired strength has been obtained, then wash in running water for at least 15 minutes and place in the regular developer for from 3 to 5 minutes, after which it should be washed again for 30 minutes.

## REDUCTION OF MOTION PICTURE NEGATIVES

### Persulphate Reducer

This formula is advised, where the film is very contrasty for it has the faculty of reducing the dense portions of the negatives without any material change in the high lights or thinner portions. Place the wet film in solution No. 1 which is made up of:

| | | |
|---|---|---|
| Water ............................ | 100 | gals. |
| Persulphate of ammonium........... | 33¼ | lbs. |

As soon as the right density has been obtained place the film in solution No. 2 which consists of:

| | | |
|---|---|---|
| Sulphite soda ......................... | 10 | lbs. |
| Water .............................. | 100 | gals. |

This will stop the reduction immediately after which film should be washed for from 15 to 20 minutes in running water and then dried as usual.

### Ferrichloride Reducer

This is an efficient method of reduction. It has been found of particular value in reducing high lights at a greater speed than shadows thereby overcoming extreme contrast.

| | | |
|---|---|---|
| Ferrichloride ......................... | 1 | dr. |
| Hydrochloric acid ..................... | .2 | dr. |
| Water .............................. | 10 | oz. |

The negative to be reduced is first thoroughly washed until the last traces of hypo are eliminated. It is then immersed in the reducer for a minute or so. On taking the negative out from this solution, no action will be apparent, but on transferring it to a freshly mixed hypo bath, reduction will take place very quickly. The operation should be carefully watched, being stopped a little short of completion.

### Ferricyanide or Farmer's Reducer

This reducer acts differently than those given above as it increases contrast by attacking the shadows more than the high lights. It must be freshly prepared as it deteriorates rapidly.

To prepare it, take as much fresh hypo solution as is required to cover the film and add to it enough of a saturated solution of potassium ferricyanide to make it lemon colored. If the color is too deep, verging on the orange, the reduction may proceed too rapidly to be controlled. When reduction has proceeded far enough, wash quickly to prevent further action.

### Dye-Toning Positives

Dye-toning is different from either toning or tinting in that a dye image is substituted for the silver one.

The dyes used for tinting film are not suitable for this process as only certain basic dyes may be used. The process is based on the discovery that silver iodide acts as a mordant for certain dyes.

To convert the silver image to silver iodide it is first immersed in the following solution:

Sol. A.—In four quarts of water dissolve 7 pounds of potassium iodide. In this iodide solution dissolve 3 pounds of iodine scales and then add to it 32 gallons of water for one rack tank.

In this bath the film must remain until the image has bleached to a pale straw color, when it is removed and washed, then placed in one of the following solutions:

| | | |
|---|---|---|
| Green | Malachite Green | 1 lb. 2 oz. |
| | Water | 32 gals. |
| Blue | Victoria Blue | 3 oz. |
| | Water | 32 gals. |
| Yellow | Auramine | 2 lbs. |
| | Saffranine | 7 dr. |
| | Water | 32 gals. |
| Red | Ponceau Red | 2 lbs. |
| | Water | 32 gals. |
| Orange | Acridine Orange | 1 lb. 12 oz. |
| | Water | 32 gals. |
| Violet | Violet de Paris | 4½ oz. |
| | Water | 32 gals. |

The iodized film is allowed to remain in the dye bath until the image is saturated with color to the back of the film. It is then removed and the high lights cleared by immersion in:

| | | |
|---|---|---|
| Bath B | Glacial acetic acid | 1 lb. 6 oz. |
| | Denatured alcohol | 5 lb. |
| | Water | 32 gal. |

The next step is the removal of the iodized silver which may be done in the following bath:

| | | |
|---|---|---|
| Bath C | Hypo | 15 lbs. |
| | Sodium acetate | 10 lbs. |
| | Tannin | 10 lbs. |
| | Water | 32 gals. |

After clearing, the film is washed and dried.

Bath C is not absolutely necessary if the film is simply dye-toned to obtain a pleasing color but for color photography where a transparent image is required Bath C must be used.

### Concentrated Developer for Gaslight Papers

| | | |
|---|---|---|
| Metol | ½ | oz. |
| Sodium sulphite (Anhyd.) | 1 | lb. |
| Sodium carbonate (Anhyd.) | 12 | oz. |
| Hydroquinone | 2 | oz. |
| Potassium bromide | ¼ | oz. |
| Water | 1 | gal. |

For use, dilute with four parts of water.

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